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ON THE COVER

The rainbow of garnet varieties includes green demantoid and emerald green uvarovite, both discovered in Russia in the 19th century. (Photo by Earl Lewis)

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Russian Demantoid

This Gem Has a Colorful History

Story by Yuliya Korchevskaya / Photos by Michael Leybov

Through the centuries, precious stones have retained their power over people's senses and imagination. From 1885 to 1915, the gem connoisseurs of England and America, under the influence of Darwinian theory, had chosen only green precious stones because the color green symbolized nature. Ural demantoid was "the green melee stone of the knowledgeable" ("Demantoid Garnet," by Jino Hammid, *Modern Jeweler's Career Profile*, page 49, 1988).

The Ural Mountains of Russia are a very popular area for precious and semiprecious stones, including emeralds, alexandrites, tourmalines, amethysts, malachites, topazes, and rhodonites. The Urals also gave the world a series of new gemstones, specifically two rare garnets discovered in the last century: emerald-green *uvarovite*, named in honor of Count Uvarov, the president of the Russian Academy of Sciences; and the tendergreen *demantoid*, flush with bright red sparkles on diamondlike faces.

Demantoid, $3CoO{\cdot}Cr_2O_3{\cdot}SSiO_2$, is a beautiful green precious stone belonging to the group of calcium-ion garnets, a rare, jewelry-quality variety of andradite named in honor of noted Brazilian mineralogist José Bonifácio de Andrada e Silva. Demantoid consists of 35 to 50 percent silica (SiO_2), alumina (Al_2O_3), 0 to 70 percent chromic oxide (Cr_2O_2), 31 to 51

VLADIMIR CHERNOVTSEV COLLECTION

This brown jasper plate, made in 1891 and associated with tsar Nicholas II, is decorated with many gemstones, including Russian demantoid.

Demantoid's indexes of refraction and dispersion are both high, and faceted stones often show a fine play of prismatic colors.

SERGEY BASKAKOV COLLECTION

From 1885 to 1915, English and American gem connoisseurs preferred green precious stones because the color symbolized nature.

percent ferric oxide (Fe_2O_3), ferrous oxide (FeO), 32 to 90 percent manganese oxide (MnO), and 0 to 21 percent magnesia (MgO).

The name is derived from the Dutch word *diamant* (diamond), since this garnet has the intensive luster and play of a diamond, observed particularly in the cut stone. The luster is strongly vitreous, inclining to greasy, while the transparency and purity of the mineral is usually perfect. It is the only stone from the group of garnets (with the exception of rhodolite from North Carolina) that is sometimes transparent. The indexes of refraction and dispersion are both high, and by artificial illumination, a faceted stone often shows a fine play of prismatic colors. Demantoid is softer than garnet or quartz at Mohs 6.5. Its specific gravity ranges from 3.82 to 3.85.

Demantoid characteristically contains microscopic, curving, feathery inclusions of fibrous actinolite called horsetails. Ironically, these inclusions increase the value and appeal of the gems.

Because of demantoid's yellow-green color, the shade that is most frequently seen, this mineral was at first thought to be chrysolite, and is even known by this name in the Urals. In Russian museums, catalogs and lists often erroneously call demantoid chrysolite. Even the lapidaries of the Ural Mountains used this name. In his fairy tales, the famous writer P.P. Bazhov wrote that "this gem is distinguished, although it is also called 'chrysolite' for its special green color resembling green grass in spring time[,] for its bright sparkling pear in faceting stones. ... This stone is so valuable that you cannot afford to use it just for pendants. It is a special variety of chrysolite only for very special jewelry" ("Garnet: Magic of Stone Demantoid," by Tatiyana Gladisheva, *100 Golden Centuries*, page 243, 2000).

"Demantoid may be distinguished from chrysolite," wrote gemologist Max Bauer, "by its single refraction and high specific gravity, demantoid sinking in the heaviest liquid[,] while chrysolite (olivine) floats" ("The Garnet Group," *Precious Stones*, Vol. II, page 362, 1968). Demantoid commonly occurs either as isolated irregular grains or more in nodules with grooved surfaces. The nodules measure from ½ inch to 2 inches. The lapidaries of the Urals called them by the felicitous name "seeds of asbestos." Distinct crystals of demantoid, the rhombic dodecahedron and icositetetrahedron, are rarely found. Combinations of these two forms have, nevertheless, been observed. Also, it is possible for the isometric and massive grains of demantoids to meet.

The grains are 2 to 5 millimeters in size, even reaching 8 to 10 millimeters. Larger crystals are very rare, although two large gems of 29.8 grains and 50.5 grains were mined in the late 19th century in the Urals. Those stones are considered unique. The largest faceted specimen of demantoid from the Ural Mountains is a magnificent 8-carat stone in the private collection of New York dealer Ralph Esmerian, of R. Esmerian Inc.

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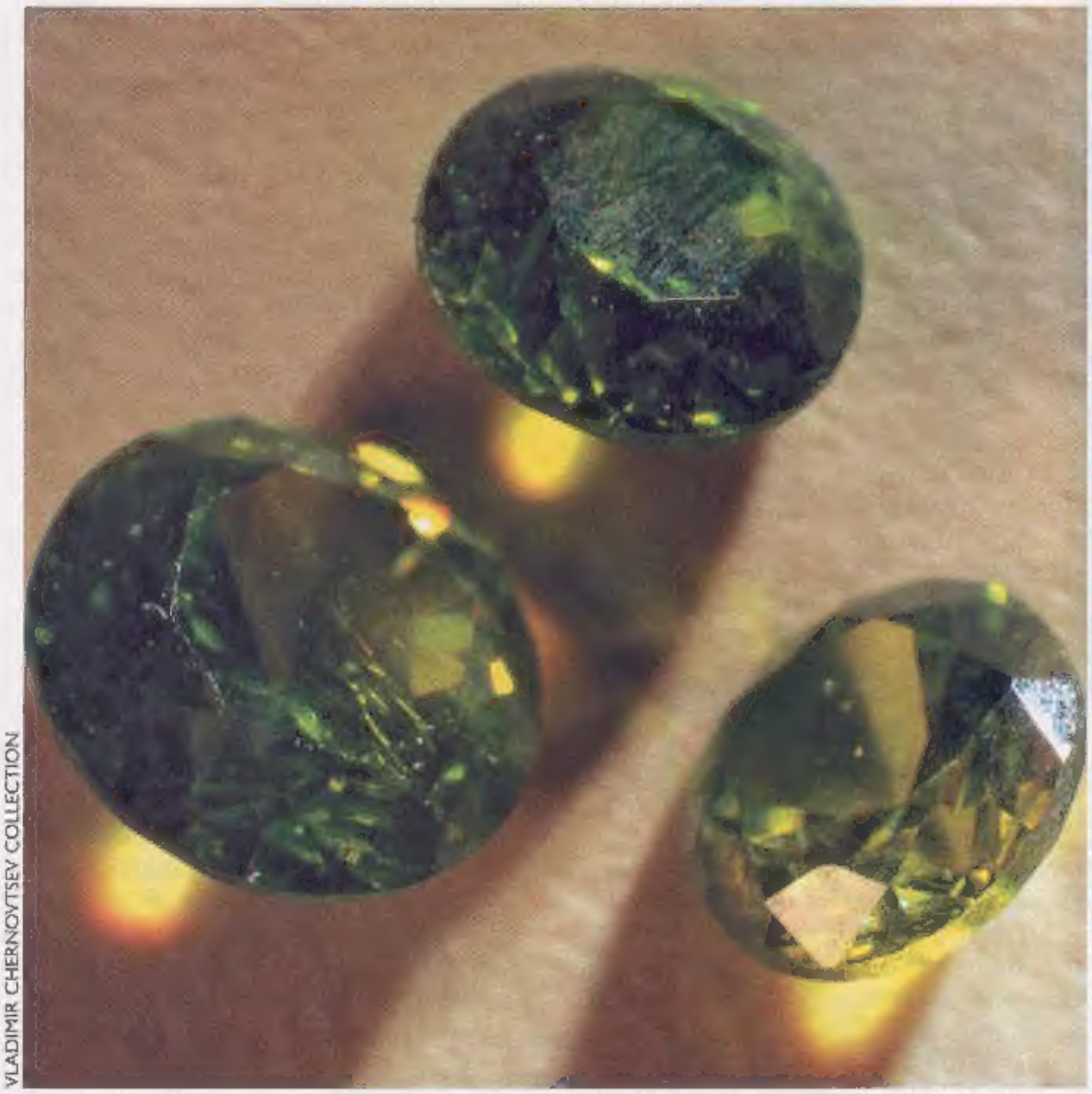


VLADIMIR CHERNOVTSEV COLLECTION

Demantoid is one of two rare green garnet varieties discovered in the Ural Mountains during the last century.

The range of demantoid color includes a fine emerald green, grass green, olive green with pistachio-yellow tints, and a brownish or yellowish green. The grass-green or olive-green colors are due to iron impurities, while a chromium impurity makes the color even more emerald green, which greatly enhances its value. Brown tints are caused by the presence of three-valence iron, and yellowish tints are caused by the presence of titanium. The best-quality raw material produces green and grass green gemstones (emerald-green coloration), with defectless grains more than 3 millimeters in size. In jewelry production, demantoid, in spite of its moderate hardness, but due to its beauty and rarity, is valued much more highly than other precious garnets.

Among the gem connoisseurs, démantoid was truly considered a Russian traditional (national) stone, much like malachite, rhodonite and alexandrite, mainly because this mineral was found only in the Ural Mountains. It is believed that demantoid was first discovered in 1868 in a region of gold deposits at the Nizhnya Bobrovka River, in the vicinity of the village of Elizavetinskoye (close to Nizhni Tagil). It was found by the famous mineral collector and traveler Nils Adolf Nordenschild, the son of Nils Gustov Nordenschild, who discovered alexandrite in the Urals in 1864.

However, at that time, no description of the chemical composition of demantoid was made. The mineral was first analyzed when it was discovered in 1884 by N.V. Kalugin in the southeastern part of Yekaterinburg (the Poldnevskoye deposit). In this region, the finest-quality stones were found, making the Poldnevskoye deposit very famous.

By the beginning of the 1890s, the Bobrovskoye and Poldnevskoye deposits in the Yekaterinburg district were exhausted. However, during this same period, demantoid was found at the prospective Korkondinskoye deposit in the Cheliybinskaya district. Nevertheless, the famous academician A.E. Fersman, poet of the stone, adduced information that during excavations at Ecbotan (former capital of the ancient country of Midia, located in the area of modern Iran, Azerbaijan and Armenia), grains of Ural demantoid were found.

So it is possible that the history of the demantoid began much earlier than is generally accepted. Midianites, Scythans and Sarmats, leading a nomadic life in the South Ural, created amazingly high-quality, artistic gold articles that were adorned with precious stones mined in the Urals. Used as gifts or commodities, the demantoids probably traveled to India from deposits in the Urals, discovered, perhaps, by the Sarmats approximately 2,000 years ago.

VLADIMIR CHERNOVTSEV COLLECTION

Demantoid ranges in color from fine emerald green through grass green, olive green with pistachio-yellow tints, and a brownish or yellowish green.

At the end of the 19th century and at the beginning of the 20th century, this gem, along with emerald, was the main precious gemstone for Russian export. During the period 1910-13, approximately 360 kilograms were exported from Russia to Paris, London, Berlin, and the cities of North America. Even today, Ural demantoid is in favor and of high value, with the main mass of the gems continuing to be exported as before. Thirty years after Ural demantoid was discovered, the great gemology pioneer George F. Kunz laid the foundation for the interest in Ural demantoid among U.S. amateurs. He was in the Ural Mountains of Russia, buying every rough piece of demantoid he could find. Thanks to Kunz, Gill estimates, one out of every 10,000 pieces of Victorian jewelry used demantoid.

Many famous figurines of animals with eyes made from demantoid were manufactured by Fabergé firms and are currently in museums and private collections. The tender green of demantoid, being in harmony with gold jewelry, was especially used for decorative, whimsical necklaces and pendants. In jewelry, demantoid was combined with opal, freshwater pearl, blue and gold topaz, and, less frequently, with ruby, sapphire-almandine, and garnet-almandine, or pyrope. Brightly glittering crystals of demantoid emphasized sophistication in the Russian Modernist style.

My family had wonderful ancient articles: a gold necklace and a pendant decorated with demantoid. This jewelry, made in the typical Russian Modernist style, was inherited from my great-great grandfather, Prince Holytsyn. The necklace was made from different hallmarks of blue and gold in the shape of decorative, sinuous sprouts with brightly sparkling green demantoid. A flexible pendant resembled a sophisticated gold harp (approximately 2 centimeters by 1 centimeter) in the framework of different-colored gold leaves. Within the leaves were mounted, like berries, amazing ruby and demantoid gems. Unfortunately, 12 to 14 years ago, Russian mineralogists defined these gems as chrysolite (precious olivine). After the collapse of the Soviet Union, I had to sell these unique pieces of jewelry in Moscow in order to finance moving my son to Moscow for the sake of his career. The jewelry was immediately bought by an Englishman for a fraction of its true value. The Englishman realized that the jewelry was demantoid rather than chrysolite, and took advantage of our misinformation.

Among the most elegant items made at the turn of the 19th century and decorated with demantoid is a large (32 centimeters in diameter) plate on display in Moscow's Fersman's Museum of the Russian Academy of Sciences. This plate is made of the brown jasper of Orck, and is adorned with silver, gold, and precious and semiprecious stones. This plate was created in the splendid style typical for the tsars' dishes and tableware. On top of the jasper plate, a gold crown is engraved and strewn with emeralds, sapphires, alexandrites, topazes, and beryls. The writing under the crown is decorated with various gems. The most interesting are the demantoid garnets in the monogram of "Prince N," representing the heir to the throne, Nicholas II, and rare alexandrite in the monogram "A," representing Aleksandr II. At both sides of the initials, there is a date: July 15, 1891. The dedicating inscription is made of topaz and amethyst: "A gift from Bashskirs of the Orsk district." Below, there is an emblem of the Gubernia made of ornamental stones: jasper, cocholong, selen-

ite and chalcedony, in a framework of green sprigs of serpentine.

The plate was made in 1891 in the Lagutin workshop in Yekaterinburg. This masterpiece is associated with the last Russian tsar, Nicholas II. In 1891, as crown prince and heir to the throne, Nicholas made a trip around the world. On his return from Japan, he visited Russia's largest cities, where many large parties were held in his honor. Nicholas II received many gifts, one of which is a real masterpiece: a commemorative jasper bowl. The local peasants and the native Bashkirs presented this traditional bread-and-salt dish on a silver plate and on a wonderful jasper plate.

According to popular belief, a garnet of any color, especially demantoid, increases success in affairs. A stone with green shades, including demantoid, brings a lot of misfortune for anyone born under the constellation of Aquarius, but is favorable for those who were born under the constellation of Sagittarius or Leo. In ancient times, the garnet was considered a sacred stone, and those who wore it gained considerable power over other human beings. In Europe, the garnet symbolized loyalty, constancy, belief, allegiance, and strength.

The green garnets (first among these, the demantoid) could be wonderful talismans for sculptors, artists, poets, musicians, and modelers. The demantoid mounted in gold consolidates spiritual strength and provides the opportunity to predict the future, so astrologists and prophets often have worn rings with demantoids. Unfortunately, recent placers of demantoid in the Urals have become exhausted. Nowadays, demantoid is mined in Australia, Egypt, Zaire (African green garnet, or tsavorite, discovered in 1971), Italy, Korea, and Norway. But for true gem connoisseurs, only Ural demantoid, gleaming and shooting with bright sparkles, remains the height of perfection.

During the last decade, at Sothebys auctions, the price of Russian antique jewelry with demantoid, depending on the quality of the stones, usually begins at $5,500. Fortunately for Russia, placers of demantoid with tints of blue were discovered on the peninsula of Kamchatka in the 1970s.

Will the future fame of Russian demantoid be as glorious as it was in the past? Will it find its place among the extensive variety of other Russian gemstones? We, the Russians, want to hope for that!

SHOP TALK

William A. Kappele

Creative Lapidary Equipment

If my e-mail and snail mail are any indication, then homemade tools and equipment are two of the favorite topics of a lot of *Rock & Gem*'s readers. So this month, I thought I would talk about some of the more unique homebuilts that I have come across. I am using a rather loose definition of unique. Specifically, I'll mention a number of machines built from parts that were originally intended for something quite different from lapidary.

I once built a vacuum casting unit that used an air-conditioning compressor from Pick-Your-Part, an automobile wrecking yard where the customer went with his own tools and removed whatever part(s) he wanted. I guess the folks who made the compressor never dreamed that one day our son Richard would be casting rings with it instead of blowing cold air on himself. (If you would like to try to make one yourself, see the article "How to Make a Vacuum Caster" in the June 1991 issue of *Rock & Gem*.)

Buoyed by my success with the vacuum caster, I returned to the wrecking yard and picked up another compressor and built a bead blasting cabinet. (See "Make a Bead Blaster," June 1992 *Rock & Gem*.)

But enough about my stuff. Perhaps one of the most unique adaptations of a machine to a use for which it was not intended is the cabber made by Maziar Nazari, a university professor of geology in Iran. It seems that lapidary machines simply do not exist in Iran, and the cost of buying one from out of the country is prohibitive. Not to be put off by such minor considerations, Maziar took an old juicer and had a machinist friend make him a lap to fit the shaft. He started out using sandpaper on his lap, but eventually he found two used Russian-made laps at a vendor's stall in the bazaar.

Thinking about Maziar's machine, I began to wonder whether a food processor would not work as well as a juicer, and with at least one extra benefit: the variable speeds. I'll bet you could pick up a used food processor or blender pretty cheaply. You may even have one lying around the house already. I realize it will take some

engineering and time, and lots of bits and pieces, but try to envision the look on people's faces when you tell them that you made that beautiful cabochon on a blender.

While we are in the kitchen, I have one more idea for your consideration. Some time ago, I came across an article in a woodworking magazine by a fellow who had made a horizontal grinder for sharpening his chisels, plane irons, etc. He made this machine, believe it or not, from an old garbage disposal. Why not build a flat lap or a cabber with one? OK, if you have stopped laughing and making wise remarks about my sanity and the kind of cabs I cut, think about this. With a garbage disposal, you have a waterproof motor of about ½ horsepower with a built-in drain. The price is nothing or next to nothing. The motor is probably fine, since most disposals are junked because of worn-out cutting blades, which you don't want anyhow. Granted, you will need to figure out a mounting system, make an adaptor to fasten discs to the shaft, and fit some kind of splash guard, but once again, think about those looks when you say that cab came out of the garbage disposal.

Happy creating!

Please feel free to contact me if you have a suggestion or comment about this or any of my Shop Talk columns. My e-mail is quappelle@cox.net, or write to me at 25231 Pericia Dr., Mission Viejo, CA 92691.

THE FRUGAL COLLECTOR

The ARSENATES and VANADATES

Part I:
A Colorful, Collectible Mineral Series

Story and Photos by Bob Jones

Pick up any decent mineralogy textbook and you'll find the arsenates and vanadates coupled with phosphates. This is because these three chemical groups form series one to the other, since the three metal elements, phosphorous (P), arsenic (As), and vanadium (V), can combine with oxygen to form radicals that can readily substitute for each other as a mineral develops. For example, pyromorphite is listed as a phosphate of lead, but the PO_4 radical that has combined with lead (Pb) to form pyromorphite is easily replaced if the radical arsenate (AsO_4) is available.

If the arsenate is greater than the phosphate in a mineral's structure, then the mineral isn't pyromorphite, but mimetite, a lead arsenate. If the phosphate is still the dominant radical, the

Adamite from Mapimi, Mexico, sometimes forms lovely fan-shaped crystals.

Some of the most unusual adamite ever found is this purple variety from Mina Ojuela in Mapimi.

EVAN JONES SPECIMEN

San Pedro Corralitas, Mexico, produced some of the world's finest botryoidal mimetite in huge quantities.

mineral is still pyromorphite, but the arsenate present changes the mineral's color from a very pleasing grass green to tan, brown or even orange. This leads to labeling confusion because neither of these lead minerals, mimetite and pyromorphite, is ever found simon pure. There's always a little bit of AsO_4 in pyromorphite and a little bit of PO_4 in mimetite. The ratio of one to the other determines the name of the mineral. Now throw in the mineral campylite, an arsenate/phosphate, and you make mineralogists very uncomfortable because they prefer not to use the name campylite. Instead, they go for arsenian pyromorphite, etc.

I have already described pyromorphite and mimetite in the December 2005 Frugal Collector article on phosphate minerals, so they will not be dealt with further here. This article will treat some of the other arsenates, a huge group of minerals that, unfortunately, lacks very many common species. In Part II, I'll describe the vanadates, another series member.

Consider the arsenates found in the historically interesting copper and tin mines of Cornwall, England. Some of the most beautiful arsenate minerals ever found came from these mines perched high on the rugged cliffs or nested close by the famous Cornish moors. The moors are an interesting land formation, having formed as the feldspar of the intruded granite decomposed. The reduction in size of the granite formed deep depressions partially filled with clay. Water accumulates in these depressions, forming swamps and marshes with an occasional patch of quicksand.

While the intruding granites slowly hardened to form the moors, the remaining mineral-rich hot solutions invaded the country rock, forming hydrothermal deposits of ore veins rich in copper, tin, uranium and arsenic.

While copper and tin were the major metals produced from the Cornish deposits, the secondary arsenic minerals contributed their share. There was enough arsenic in the deposits, both as arsenopyrite and a clutch of less common arsenates, to make arsenic a by-product of copper and tin mining. This poisonous metal element was extracted and sold. Life expectancy was tenuous at best in Cornwall, especially for the fellows who worked with arsenic recovery. The final product from the arsenate minerals was an exceedingly poisonous white powder. Grains of this powder floated about in the atmosphere with nary a filter in sight. The men, to avoid breathing some of the dangerous dust, wore cloth masks and stuffed cotton into their nostrils, which had minimal beneficial effect.

Austinite usually forms in dark green crystalline coatings; this specimen is nearly covered by calcite.

Olivenite, a hydrous copper arsenate, was often found in the mines of Cornwall and Tsumeb.

One of the world's most attractive arsenates is legrandite, which occurred on goethite matrix at Mapimi.

The arsenate minerals found in Cornwall are really beautiful minerals, but not common at all, so few are seen for sale today. The Cornish arsenates ceased to appear in any quantity over 100 years ago when just about all the mines shut down. Still, you should be alert for them, especially because of their rarity. Finding any Cornish arsenates for sale is a special treat, especially if they are offered for sale by a collector or dealer who is not familiar with such lovelies.

The Cornish arsenate group includes clinoclase, olivenite, liroconite and chalcophyllite. Each of these species occurred as superb specimens—in some cases the world's best—in Cornwall, but in very limited amounts. The mines that produced them were operating in the mid- to late 1700s and on into the 1800s.

Of these, the finest arsenates, such as cornwallite, ceruleite and pharmacosiderite, probably were found at the St. Day mines. Wheal Gorland (wheal means mine) and the Levant Mine produced the finest arsenates. The world's finest liroconite came from Wheal Gorland and is now in the Royal Museum in Truro. It may be seen on display there as part of the Philip Rashleigh collection. The crystal is a single monoclinic crystal that measures about 2 inches on an edge, is shaped like a triangle, and boasts a superb sky blue color. This mineral was more often found as small, intergrown crystals of perhaps 3/16 inch, usually on a brown matrix. The rich blue color makes the mineral easily recognizable.

Wheal Gorland also produced the world's finest clinoclase specimens; some of the finest reside in the Rashleigh collection. Clinoclase is normally seen as small spherules or in radial masses or reniform groupings of small, rounded masses. The Wheal Gorland specimens are superb, dark, blackish-green spheres to 2 inches across, an immense size for the mineral.

In this country, small crystal groups of clinoclase have been collected at Gold Hill and the Mammoth Mine in Utah. More often, clinoclase was found at Majuba Hill, Nevada. After the Majuba Hill mines shut down, collectors could venture underground and find nice specimens of this uncommon arsenate.

Chalcophyllite is another uncommon arsenate found in Cornwall in those early days. It is actually a widespread arsenate now, but is only found in very small amounts in Germany, France, Russia, Chile, and even New Zealand. Chalcophyllite crystals are hexagonal, usually platy looking, with a pearly luster, and form lovely emerald to blue-green rosettes. Here in the United States, the mineral was found at the Gold Hill, Mammoth, and Majuba Hill mines.

continued on next page

While the subject of this article is the compounds called arsenates, it might be well to remind readers that the metallic element arsenic is also found during mining. Actually, arsenic, though an element, is not a true metal. Rather, it is referred to as a metalloid, which means it has some metallic properties and some nonmetallic properties. It's number 33 on the Periodic Table and resides right along the boundary between the metal elements and the nonmetal elements.

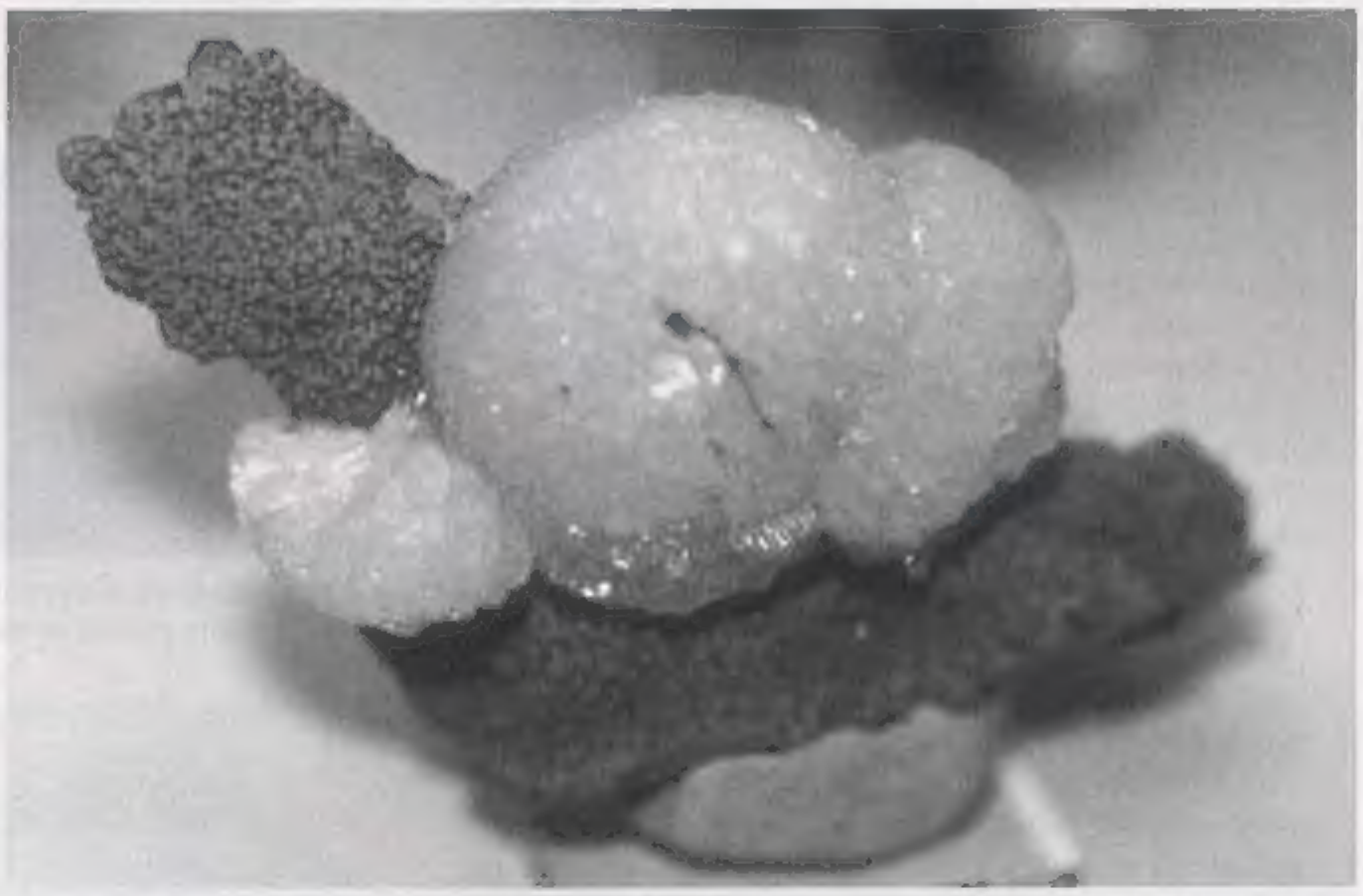
Arsenic was actually a fairly common ore in many of the early German, Czech and Romanian mines, where it occurred as a tin-white hexagonal mineral in reticulating crystals, sometimes needlelike and twinned. It also occurred as reniform massive specimens, solid undulating layers of silvery color that, when exposed to the air, turned dark gray as it combined with oxygen to form the arsenate radical. Fine specimens were fairly abundant in the early days of mining in Europe. One source for this mineral, Sainte Marie aux Mines, Haut Rhin, France, has recently become the site of one of Europe's most popular mineral shows.

In this country, a small amount of arsenic has been found at Sterling Hill, New Jersey, and it currently appears rarely at Pasto Bueno, Peru.

Of all the arsenate minerals extant, the species that has probably been the most pleasing and certainly the most abundant in the last 40 years is adamite. The irony is that before the Ojuela Mine in Mapimi, Mexico, began producing this usually green mineral in huge quantities, adamite was considered uncommon, even rare!

Adamite is a hydrous zinc arsenate that is found in minor amounts in various mines in Germany; at Caldbeck Fells and Cornwall, England; at Copiapo, Chile; and at the complex deposit at Cap Garonne, France. It has even occurred at Laurium, Greece, the source of silver that saved Greece from an invasion by the Persians and started it on the road to democracy. But adamite from any of these localities is uncommon.

The two major sources of adamite today are Tsumeb, Namibia, where it occurs mainly as cuprian adamite, and the Ojuela Mine. The adamite from Tsumeb is rich in copper, so it has a deep green color, does not respond to ultraviolet light, and is seen in radiating bundles of subparallel crystals. The specimens that have been mined there have been highly prized.



Adamite was a rare mineral until superb specimens were found in abundance at Mapimi.

Mapimi has to be the world's most important source of adamite. The mineral occurred abundantly throughout the upper oxide zone, which extends well over 1,000 feet into the ground. When the mine was working, specimens were saved in quantity, as miners early recognized their specimen value. When the mine owners decided to shut down the Ojuela Mine, the local miners formed a co-operative, obtained the mine, and proceeded to mine specimens diligently, saving virtually all the specimens encountered. These found their way into the hands of wholesale dealers who made regular visits to this remote mining camp.

In the 1960s and 1970s, it was common to be able to buy quantities of adamite from dealers for as low as $2 a pound! At one show in the early 1970s, I came across a dealer who had just returned from Mexico. He had no fewer than 20 large fruit boxes of Mapimi adamite for sale, each box holding 20 or 30 specimens ranging from superb cabinet-sized groups to equally choice miniatures. In those days, the flow of adamite was unceasing and it was never a matter of finding good specimens, but deciding how many good specimens you could afford to buy.

Adamite from Mapimi comes in a variety of crystal forms, with radial aggregates the most common. Single orthorhombic, transparent blades in small groups are less common. Of particular appeal are the fans of radiating crystals, which start at a single point and fan out in clusters ½ inch to 1 inch or larger. Tightly grouped crystals often cover the matrix completely. The complete balls of adamite found here are very appealing, their surfaces a sparkling array of terminations.

Mapimi adamite ranges from nearly colorless to lime green to light yellow, honey yellow, and even reddish to purple. The bluish material contains a small amount of copper ions. The bright green adamites respond brilliantly to ultraviolet excitation. As the copper content in the adamite increases, the UV response diminishes, since copper is a quencher of UV.

The most interesting and most highly regarded adamites are those violet-colored blades that were mined at Mapimi early in 1982. In researching the year these purple adamites first appeared, I came across a comment that graphically illustrates how abundant adamite was the those days. In *Mineralogical Record* (Vol. 13, No. 1, page 39), a writer states, "Many collectors might yawn at the mention of more adamite from the famous Ojuela mine ... ." Imagine the quantity that could have provoked such a statement. The article goes on to describe the earliest appearance of violet-purple adamites from Mapimi.

The largest quantity of this purple zinc arsenate appeared at the Tucson Show in 1983, where specimens sold for three and four figures! The finest crystals were in diverging clusters with deep royal purple tips that gradually lightened to colorless or light green at the base. The purple color was first reported as being due to manganese as a chromophore, but later studies showed pink to violet to be due to cobalt as a chromophore. In the green variety, copper

acts as the minor, but important, chromophore. Adamite shows a strong fluorescence if the amount of copper is minor. The brilliant green response to ultraviolet excitation is due to a trace of uranium salts, a universally popular activator. If you happen to own a copy of my "50 Year History of the Tucson Show," check out page 84. Both purple adamite and the world's finest hroconite are figured there in color.

Cuprian adamite is best known from Tsumeb, where it occurred in several finds during the 1980s. The crystals, which were upwards of 2 inches at times and a deep emerald green, were initially identified as dioptase and sold as such. They were even mistaken for olivenite, which is another arsenate. This is because if the copper content is high enough, adamite actually becomes olivenite, a copper arsenate. Later examination showed these "olivenites" were adamite, the world's finest! So when you are checking minerals that are labeled dioptase, watch for anything a bit odd, especially crystals that tend to fan out slightly and show that deep green color. In this case, the copper content in the Tsumeb adamite is not high enough for it to be called olivenite, so the name cuprian adamite is used.

Clearly, adamite forms a series with olivenite, the most common secondary copper arsenate to be found in hydrothermal deposits high in copper content, such as Tsumeb. That does not mean you'll find hundreds of specimens of this olive-green to green-brown mineral at every show. Olivenite is not abundantly available from any source.

When we describe two minerals as forming a series, this simply means the atoms of the two metallic elements involved – in this case, zinc and copper – are close enough in size and electron arrangement that they can substitute for each other. Note, however, that the crystal form of each species differs, which means the atoms do not arrange themselves the same way internally.

Unlike some species that form a series, the adamite-olivenite series does not boast named species of intermediate composition, in which the two metals are more or less equal. Such combinations in this series are simply referred to as zincian olivenite and cuprian adamite according to the dominating metal cation.

The Tsumeb olivenites are never exceedingly large, the better crystals are only 1 inch to 2 inches long. Still, that is quite exceptional for olivenite, which usually occurs as small, tightly attached crystal clusters or as velvety crusts.

continued on next page

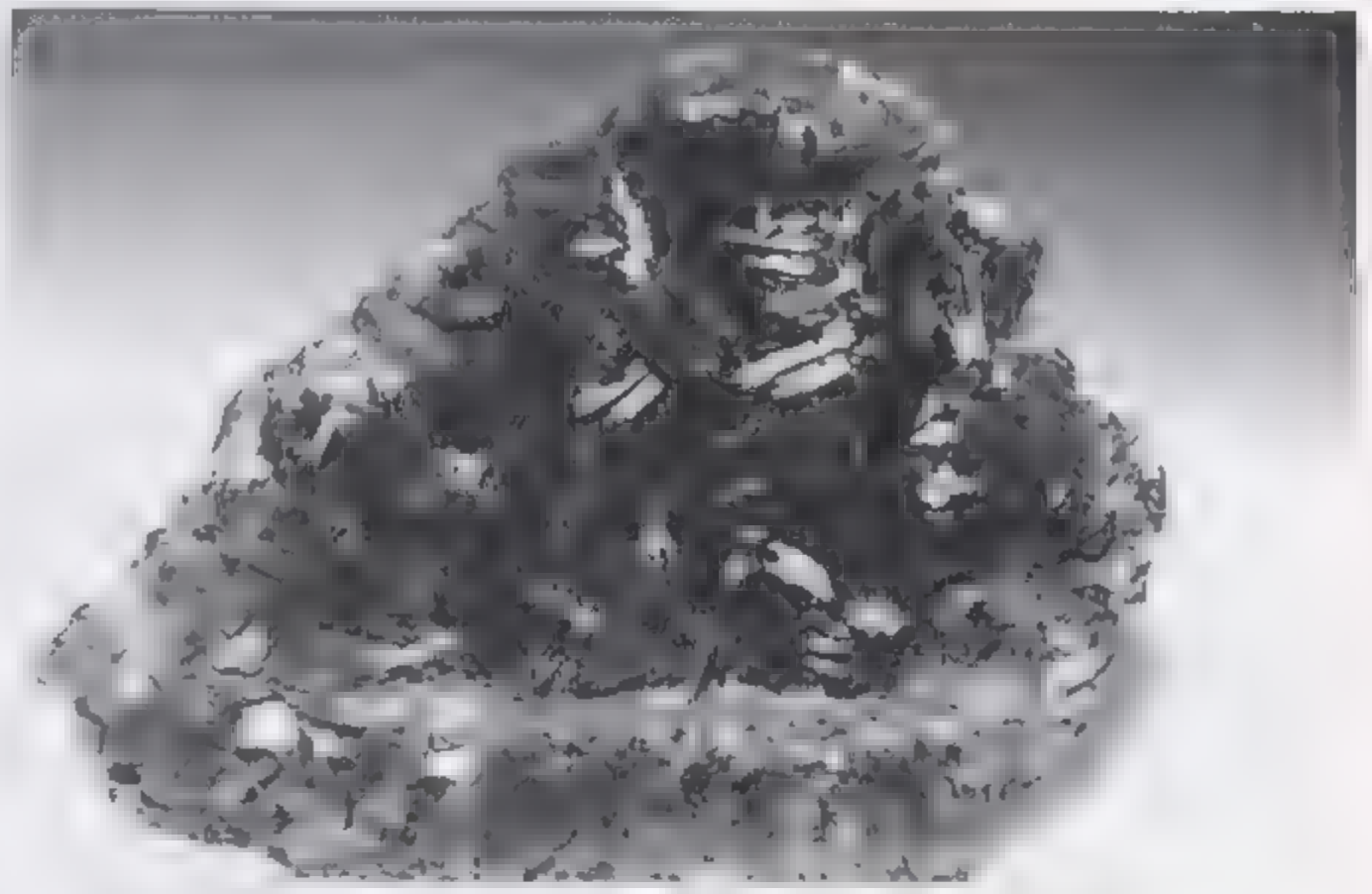
Olivenite occurs as curving lamellar clusters or in reniform layers. It is not found in as many localities as adamite, the best known source is Tsumeb, Namibia. It is also found in Touissit, Morocco, Chile, Majuba Hill, Nevada, and the Tintic District of Utah. Some of the very nicest specimens of olivenite, with small, tightly packed crystals covering the matrix, have come from the mines of Cornwall. Again, most of these mines shut down over 100 years ago, so don't expect to see any Cornwall olivenite at mineral shows.

Here in the Southwest where Mexican minerals are more common than anywhere else outside that great country, two green minerals, conichalcite and austinite, cause all sorts of identification trouble for many collectors. Austinite is a calcium copper hydrous arsenate and conichalcite is a calcium zinc hydrous arsenate. They are both orthorhombic, though you'll never see distinct, discrete crystals. They form as fibrous aggregates with a radial structure or as crusts in some shade of green. The austinite tends to be a little more blue-green at times, while conichalcite can be yellow-green or colorless. The two minerals even occur together in some localities like Gold Hill, Utah, the Ojuela Mine, Mapimi, Guchab, Africa, and even Tsumeb, Namibia, where conichalcite is the most common.

To add to the confusion, there is even a cuprian austenite, and I suppose there is a zincian conichalcite in the series. When I encounter a specimen from Mapimi, with which I am most familiar, I tend to call the blue-green specimens austenite and those showing a brighter grass-green color conichalcite. Save for an X-ray or wet test, this is probably the best guise to distinguishing the two.

While most arsenates show a pretty color, the species I think is more colorfully attractive than any other is erythrite. With a marvelous pearly luster and crimson or rose to almost violet-pink color, erythrite is extremely eye-appealing. It has been known since the early 1700s when it was first found in the German silver cobalt mines. Back then, it was called kobald-bluthe in reference to its color.

"Kobald" is also the name early German miners gave the invisible goblins that caused unexplained mishaps underground. The kobalds were used to explain the grinding, groaning sounds that are produced as rocks shift when support is removed. Some thought these sounds were made by kobalds to warn of impending disaster. The Cornish miners had their goblins, as well. They called them tommyknockers.



Choice blades of erythrite came from Bou Azzir, Morocco, one of the world's best sources.

Few German specimens of erthyrite are seen today, but a new and better source, Bou-Azzer, Morocco, has produced many superb specimens. These crystals are large for erythrite, sometimes exceeding an inch. They show a superb pink-violet color, with the edges and base of crystals a darker shade. The pearly luster is prominent, and this enhances the crystal clusters.

In the United States the only notable source for erythrite has been the Blackbird Mine in Owyee County, Idaho. This mine has produced superb examples of two other species vivianite, an iron phosphate, and the calcium iron silicate axinite.

The Santa Maria Mine in Sonora, Mexico, has produced a number of colorful erythrite specimens. They are velvety, pale rose crusts or coatings on matrix. The mineral is very soft and easily crushed by a touch. Good undamaged specimens are not easy to find.

The arsenates tend to be very colorful and attractive, which makes them all popular, though they are often hard to obtain because they seldom occur in abundance. Certainly, one of the more exciting and attractive members of the arsenate group is legrandite. The reason this rare species can even be considered an available collector mineral with high popularity can be given in two words: Mina Ojuela.

The original legrandite was identified from a small, unimportant mine called the Flor de Pena Mine in Lampazos, Nuevo Leon, Mexico. The specimens collected there by a Belgian mining engineer named Legrand are small, dull yellow crystals under ½ inch and not exciting at all. The mineral has shown up in a couple of Japanese localities and in Brazil, and was recently identified from Sterling Hill, Ogdensburg, Sussex County, New Jersey. These are all very minor occurrences.

An exciting find of legrandite at Tsumeb in 1982 added a small number of fine yellow orange specimens to the list of localities, but without Mapimi, the word legrandite would hardly ever fall from the lips of a mineral collector!

The earliest legrandite from Mapimi seems to have surfaced about 100 years ago, but went largely unrecognized. Then in the early 1960s, the local miners' co-operative started finding legrandite in the lower portion of the oxide zone, some 1,200 feet below the surface. The finds continued through the next several hundred feet.

Legrandite is traditionally a straw yellow color. It has also been found at Mapimi as a dull, pale tan mineral, probably due to prolonged immersion below the water table. Mapimi legrandite generally occurs as prismatic crystals that average an inch or so in length. The crystals have noticeable striations and are well terminated. They almost always form in slender diverging sprays or in sheaflike aggregates, and rarely as single crystals scattered on matrix.

The matrix for most specimens is a hard silicified brown gossan that is difficult to trim. For that reason, repaired specimens are not uncommon. A friend of mine once bought a large lump of hard matrix with a lovely 2-inch diverging spray of legrandite, brilliant yellow and well terminated, sitting right up like a flagpole. The problem was the matrix, a huge, ugly

brown rock some 4 or 5 inches across and 2 or 3 inches thick. The matrix obviously detracted from the lovely yellow spray. Naturally, the specimen would be much improved if it could be trimmed. In those days, using a diamond saw to trim a specimen was frowned upon. Today, dealers use the diamond saw, but they have learned to use a sand blaster to re-shape the matrix surface to remove saw marks. This makes the matrix look natural.

My friend used a jaw trimmer to try to break the matrix down. Unfortunately, the legrandite spray popped off, though it remained intact. This made the matrix easy to trim. Once the matrix was of a suitable size, the legrandite spray was put back from whence it came and no one, except the owner and I, was the wiser!

If Mapimí had produced nothing but lovely yellow 1- and 2-inch diverging sprays of legrandite, some of which are very attractive bow-tie clusters, the collector world would have been more than satisfied with this lovely mineral. But in 1979, two record-breaking legrandites surfaced and sent ripples through the collector world. One of these great specimens now resides in the American Museum of Natural History collection. It is a long, tapering, narrow diverging cluster of crystals bound together. The entire spray measures over 10 inches long! This breathtaking specimen has since been named The Indian Club. By any standard, this is an exceptional specimen, and for a mineral as uncommon as legrandite, it is a remarkable treasure.

As handsome as the Indian Club is, my favorite is the second large specimen found in 1979. This beauty consists of two bright-yellow legrandite sprays made up of diverging crystals locked tightly together. The sprays head off in opposite directions, like the hands of a clock set at 10 a.m. and 2 p.m. The overall length of the cluster is 7 inches and the spread ends of each spray are about 4 inches apart. It was my pleasure to give this specimen the name everyone uses now, The Aztec Sun! *Rock & Gem* was the first publication to bring the news of this find to readers.

My introduction to these marvels of hydrous hydrate of zinc arsenate came through an evening phone call from Jack Amsbury, the dealer who bought the specimens from the miner who dug them. Jack called me from Tucson and said I should come there immediately because I would not believe what he had just gotten. He told me the whole story.

continued on next page

The Frugal Collector *from page 25*

Jack was a mineral dealer who made regular buying trips to Mapimi. On this particular trip, he arrived in the late afternoon, checked with his usual suppliers, and looked at box after box of average and below-average minerals. At one miner's home, they went through this ritual with Jack either refusing to buy or buying very little. Finally, the miner brought the two huge legrandites from under the bed. Jack realized what a find he had made and immediately negotiated a purchase. He packed his treasures and headed out of town on the only access road. As he drove along marveling at his great good fortune, another well-known mineral dealer came driving up that road. Jack feels he was that close to never having a chance at buying those legrandites. Obviously, timing had been everything. He never told the other dealer, who has since died, what a near miss he had.

Today, the Aztec Sun sits in the Houston Museum of Science display collection and is often seen at major shows as part of the Houston exhibit.

The third group of the phosphate/arsenate/vanadate chemical trilogy, the vanadates, will be described in Part II of this article. As a preview to that, here's a description of the rarest member of the vanadium group. This mineral is certainly my favorite vanadate. It is called bobjonesite!

Never in a million years did I ever think I would have a mineral named after me. It all came as a surprise and shock! I got a call one day from Joel Grice, a top-notch mineralogist in Canada. He wanted a brief biography of me to use in an article. This surprised me. Joel was even more surprised than I was when he found out I knew nothing of the reason for this request. It was to be part of the announcement that a new mineral was to be described and published.

Now it seems that Pat Haynes, certainly one of the most diligent and sharp eyed field collectors around, had been discovering new minerals one after another. At present count, Pat is credited with finding no fewer than nine new minerals. Pat's quite a fellow. He has at least one altruistic motive, and that is to name a new mineral for all those who have been awarded the Carnegie Mineralogical Medal, considered by some the highest award in the collecting field. I received this award in 1998.

As Pat continued to discover new things, he reviewed the list of Carnegie winners: John Sinkankas, Fred Pough, Paul Desautels, and so on. It seems that everyone who had been awarded the medal before I received mine already had a mineral named for them. So when Pat found something he suspected was new, he submitted it to Frank Hawthorne at the University of Saskatchewan to prove out his suspicions. Pat suggested bobjonesite as a name for the new mineral, since I was next on the Carnegie Award list.

All went well with the studies of the new mineral until Frank sent the specimens, along with his research, to the International Nomenclature Commission, the body charged with accepting the scientific work. Here, a problem arose. It seems that the new mineral, a hydrous sulfate vanadate, loses water easily. The commission could not prove the results of Frank's work because the specimens sent had lost water and become something else. But Frank did not give up. He sent in another batch, this time in a sealed container so no water would be lost. Sure enough, the commission confirmed Frank's results, and Pat's newest "baby" became bobjonesite!

So where can you collect bobjonesite? You can't! Neither can I, anymore. The original source is the North Mesa #5 mine, along the San Rafael Wash south of Green River, Utah. The mines in this area were opened to mine radioactive uranium ore and vanadium ore. Old uranium mines have proved to be a bit dangerous because of the accumulation of radon gas, so Utah has decided to seal off all such mines, and North Mesa #5 is now sealed shut permanently.

The number of specimens of bobjonesite, which consists of nice blue microcrystals on a carbonaceous matrix, is very limited, perhaps no more than a dozen or so. The mineral was found in a petrified wood log in the Shinarump conglomerate formation of the area. As the wood decayed, it was replaced, and new minerals formed. Pat has found at least three in the log.

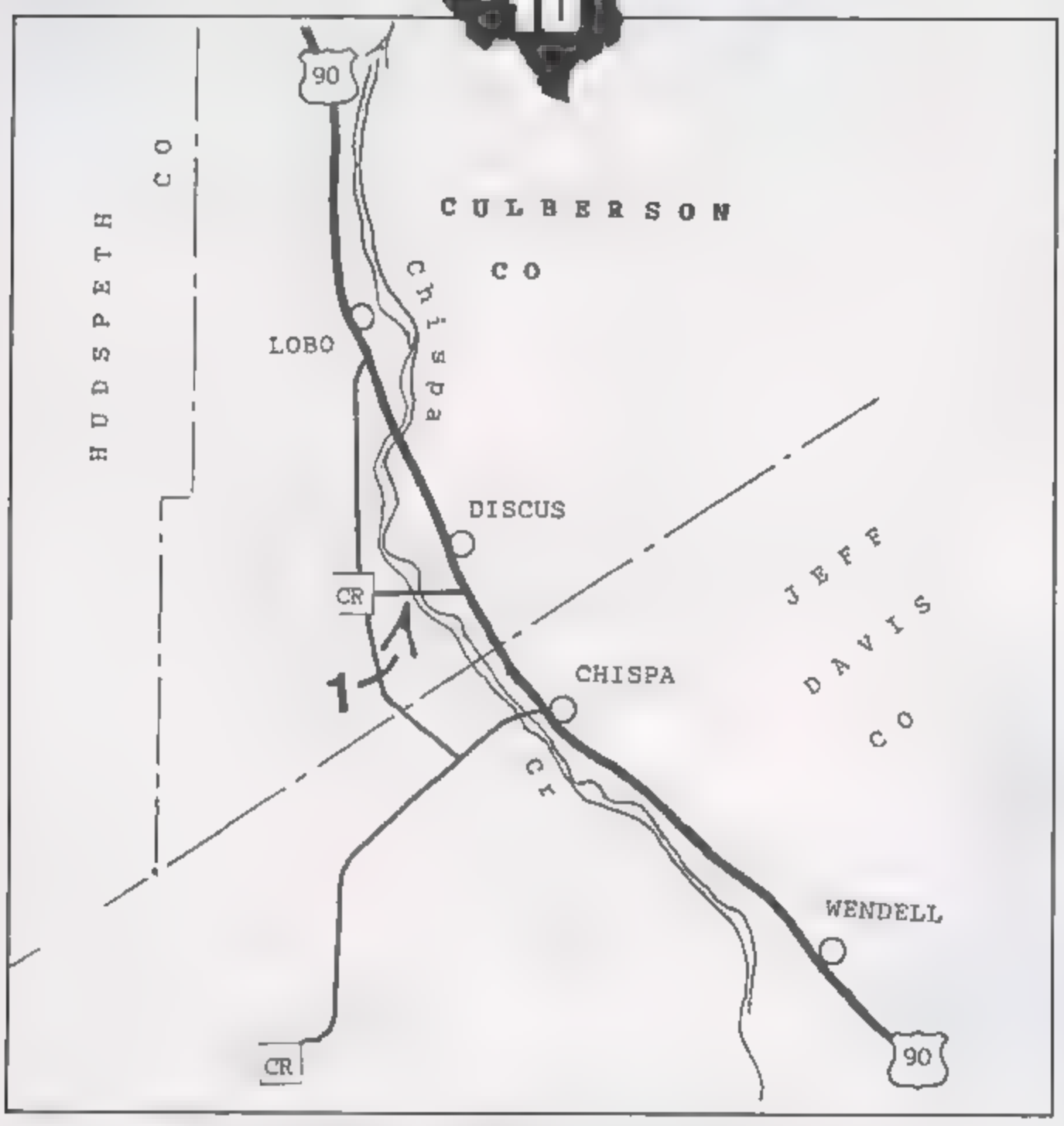
Luckily, Pat agreed to meet my sons Bil and Evan and me at Green River so we could get into the mine before the state sealed it off. One adit was still unsealed when we got there. So, wearing masks to guard against radon and carrying a scintillometer to measure radiation, we were able to collect a half-dozen specimens, which will stay with the family. I did mount one micromount specimen for my friend John Ebner. John has a wonderful project ongoing. He asks those for whom a mineral has been named to mount a micro for him. The collection will eventually end up at the Smithsonian, but for now, John exhibits his vast collection of micro specimens at eastern shows, at Tucson, and at various micromount conferences he attends. To see a bobjonesite specimen, watch for John's exhibit.

GOLD AND GEM HIGHWAYS

ROADSIDE PANNING SITES IN TEXAS

Part II: 10 Counties Offer Gold, Agate, Jasper and More

Story and Maps
by David and Clois Walker



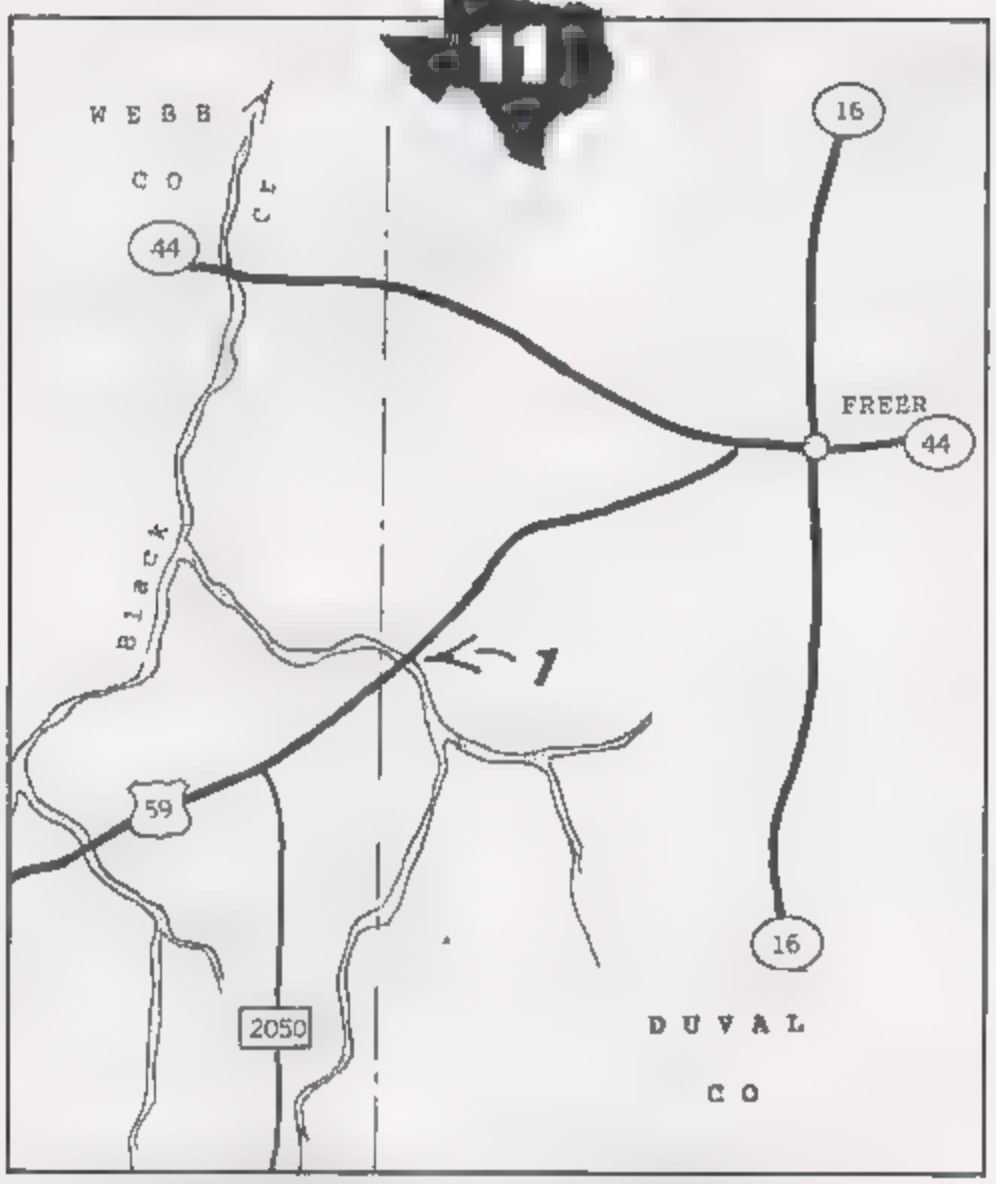
CULBERSON COUNTY (MAP TX10)
Site 1 **Chispa Creek/County Road** crossing near **Discus.**
Variety finds indicate gold potential

This is the second in a series of six articles containing county-by-county maps to suggested panning and screening sites at Texas highway/stream crossings where appreciable finds have been previously reported in vicinity watersheds. The principles of erosion make it likely that minerals and gem stones have been deposited in river gravels, awaiting removal by a rockhound with a pan.

By confining operations to within government purchased highway rights of way, panners are spared the necessity of locating and obtaining permission from adjoining property owners, including state and national parks and Indian reservations. However, readers run the risk of prosecution if they cross onto private land, whether purposely or inadvertently. In instances where rights of way have merely been leased, other rules may apply. Visitors are urged to inform themselves of possible limitations by calling (512) 225-1462 *before* making a trip. The Texas Annual Vacation Guide, as a companionate source of information, is available by calling (800) 888-8839.

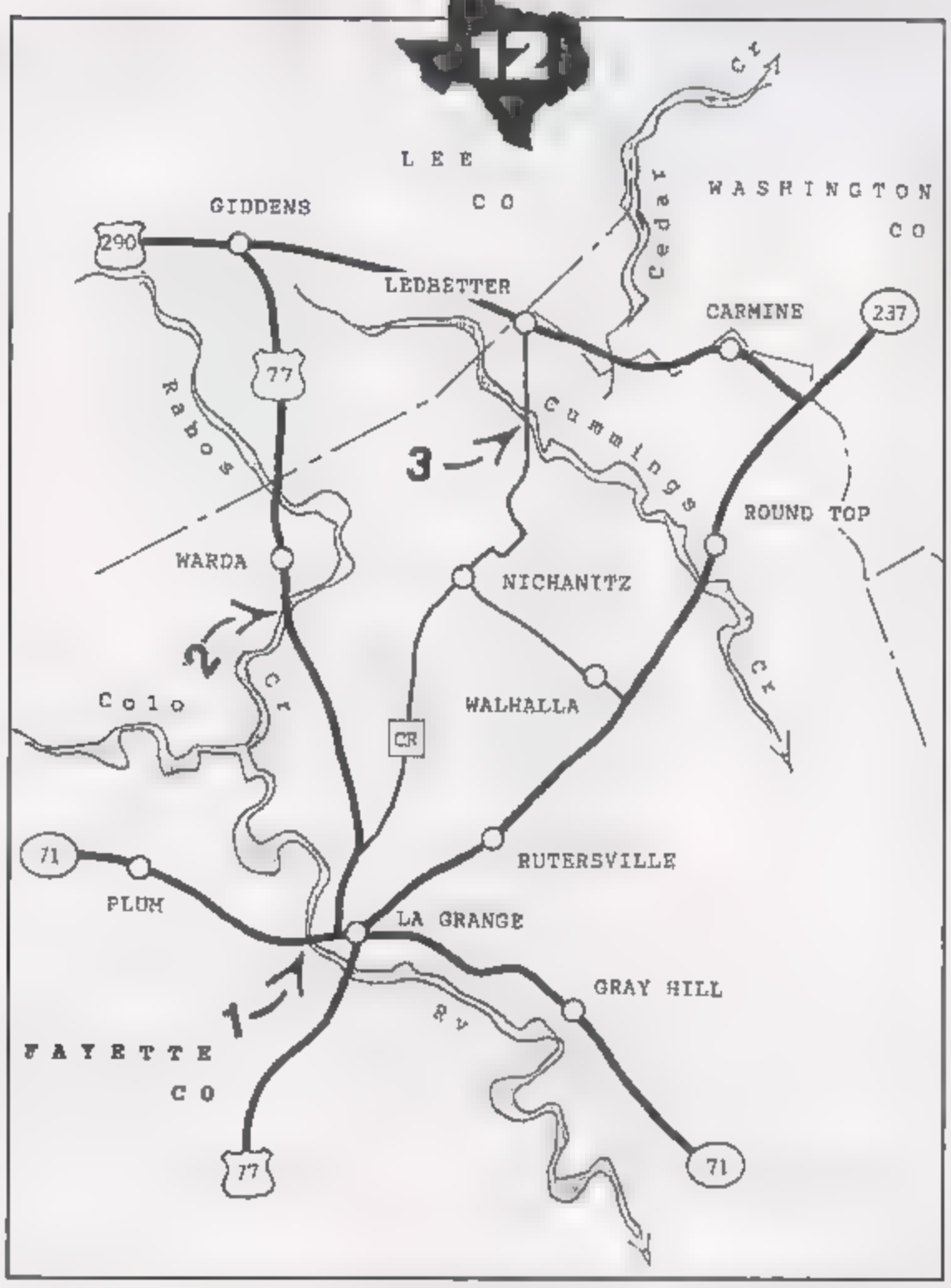
Remember that the government to which these rights of way belong has some regulations of its own. Observe highway safety and environmental standards, such as parking only where designated, and using only a pan and scoop—no heavy equipment.

The maps provided contain the most up-to-date information available to us, but it is advisable to consult a current state highway or county map when planning an outing for overall orientation in the field and because highway designations have been known to change.



DUVAL COUNTY (MAP TX11)

Site 1 **Tributary Black Creek/U.S. Highway 59** crossing near **Freer.** Vicinity finds indicate silicified wood potential

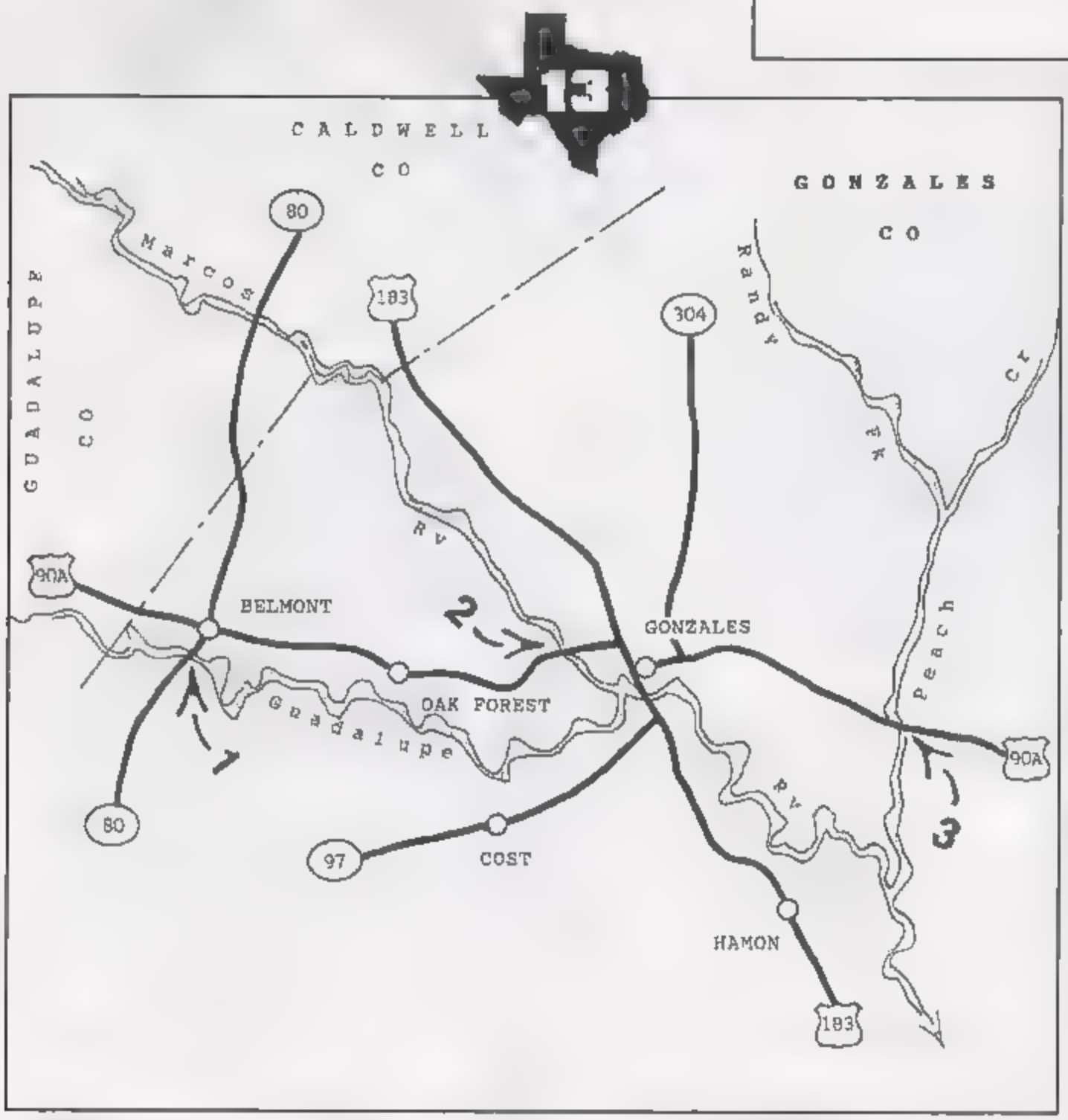


FAYETTE COUNTY (MAP TX12)

Site 1 **Colorado River/state Route 71** crossing near **La Grange.** Vicinity finds include jasper, opalized wood, palm wood, and silicified wood

Site 2 **Rabos Creek/U.S. Highway 77** crossing near **Warda.** Vicinity finds include opalized wood and silicified wood

Site 3 **Cummings Creek/County Road** crossing near **Ledbetter.** Vicinity finds include opalized wood and silicified wood



GONZALES COUNTY (MAP TX13)

Site 1 **Guadalupe River/state Route 80** crossing near **Belmont.** Vicinity finds indicate onyx potential.

Site 2 **Marcos River/U.S. Highway 90A** crossing near **Gonzales.** Vicinity finds include onyx and palm wood.

Site 3 **Peach Creek/U.S. Highway 90A** crossing near **Gonzales.** Vicinity finds include agate, palm wood, and silicified wood

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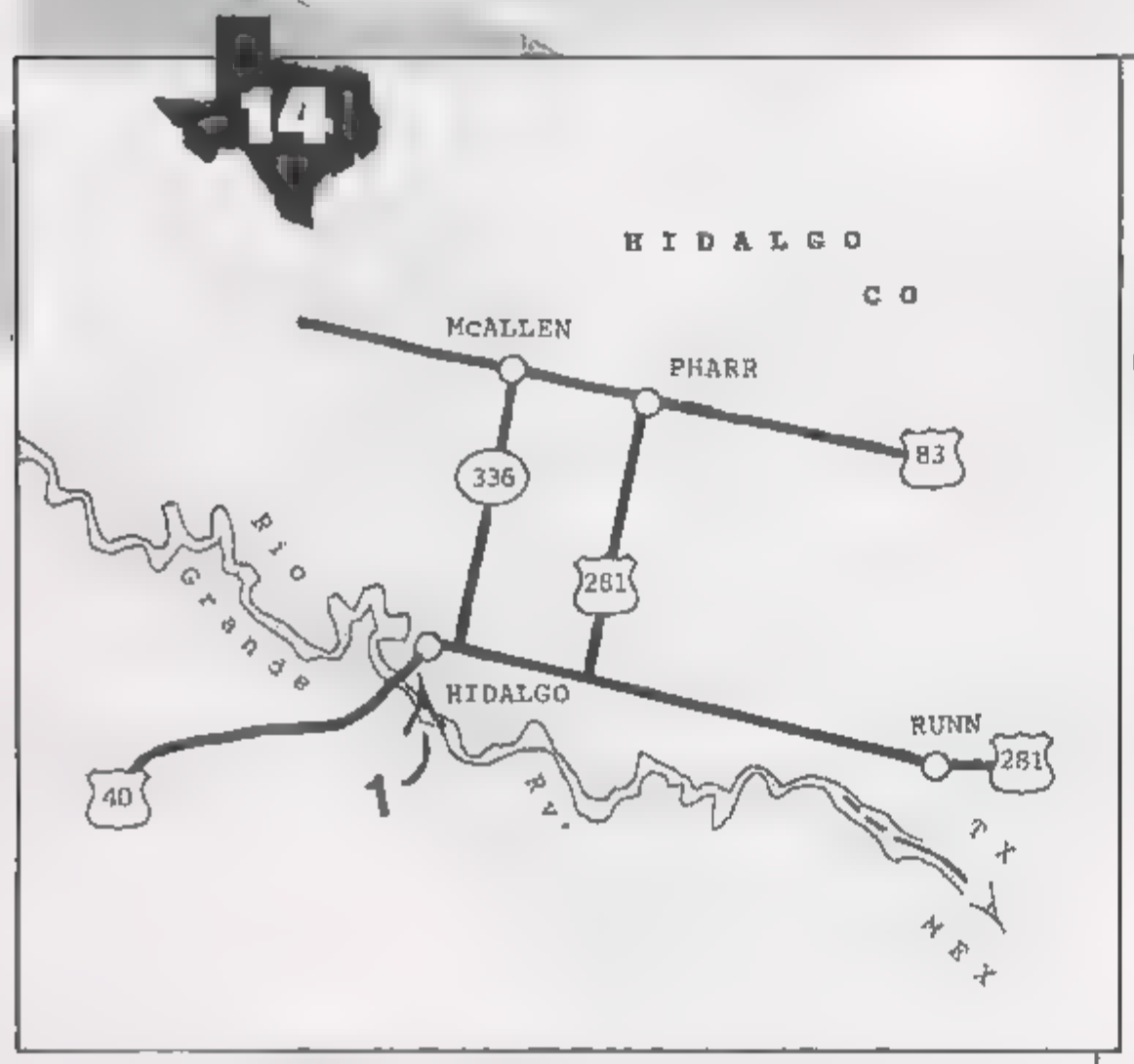
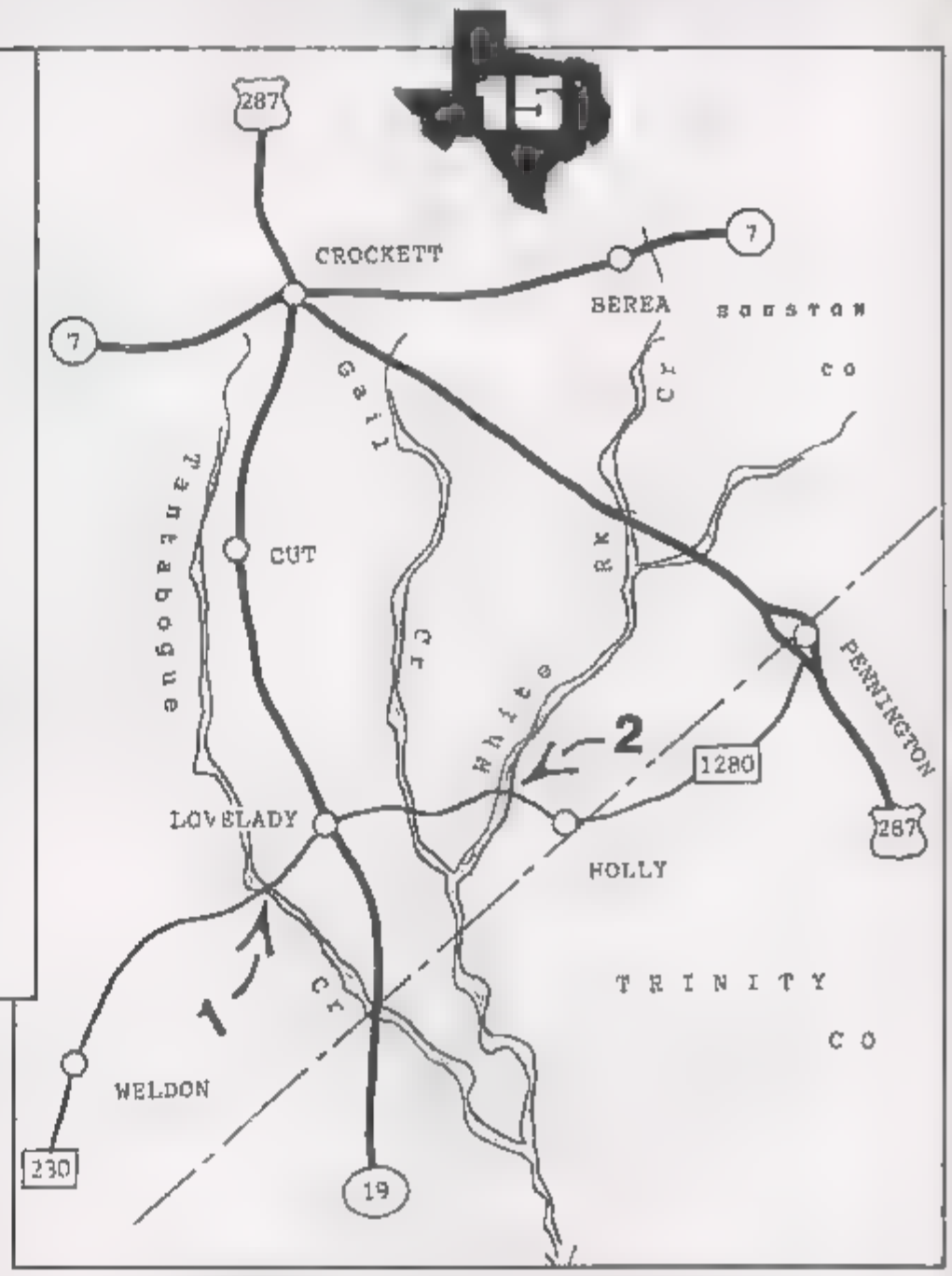
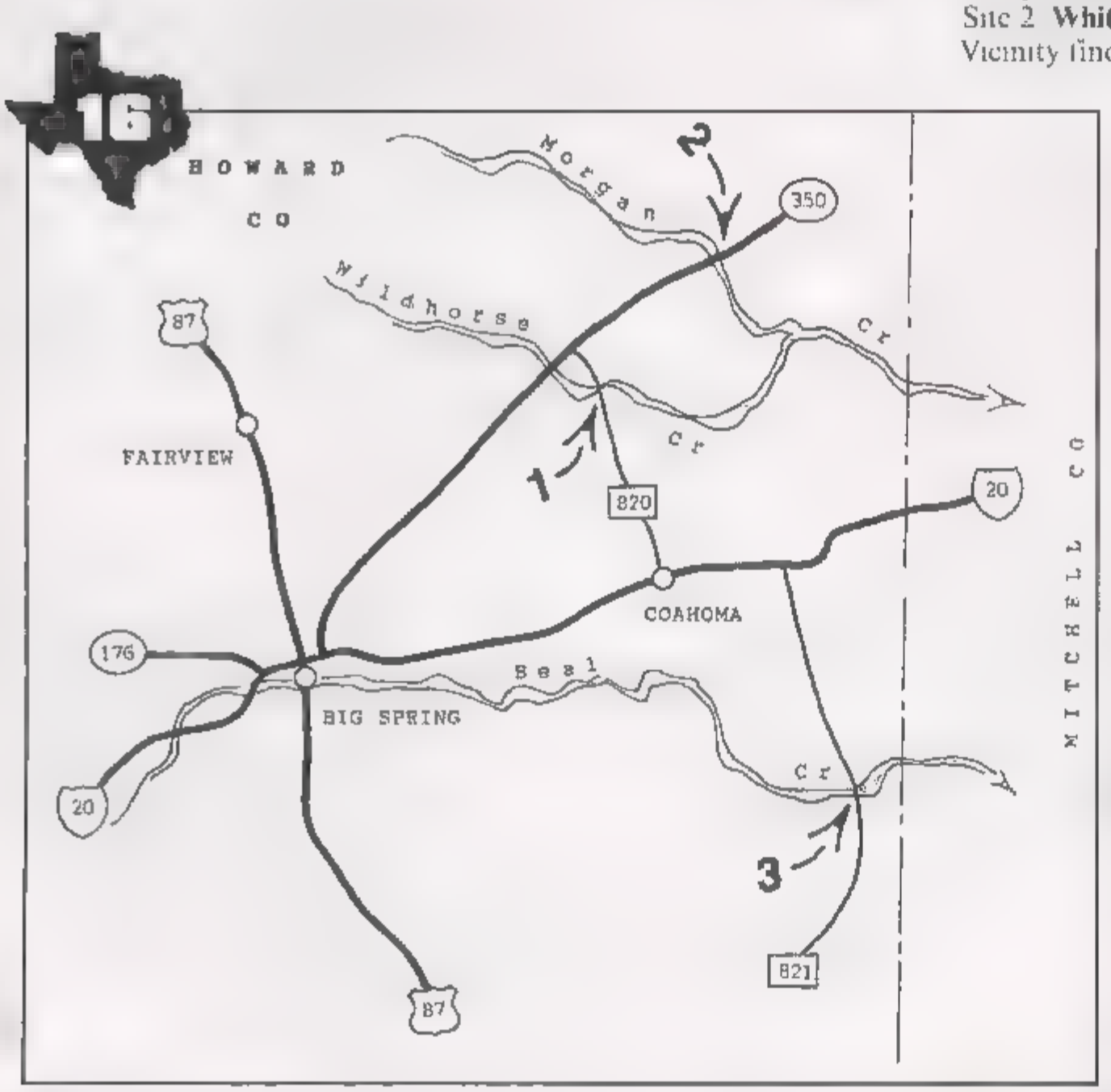


HIDALGO COUNTY (MAP TX14)
Site 1. **Rio Grande River/U.S. Highway 40** crossing near **Hidalgo.** Vicinity finds include agate, jasper, and silicified wood



HOUSTON COUNTY (MAP TX15)
Site 1. **Tantabogue Creek/FMR 230** crossing near **Lovelady.** Vicinity finds include jasper, opalized wood, and palm wood.
Site 2. **White Rock Creek/FMR 1280** crossing near **Holly.** Vicinity finds include jasper, opalized wood, and silicified wood.



HOWARD COUNTY (MAP TX16)
Site 1. **Wildhorse Creek/FMR 820** crossing near **Big Spring.** Vicinity finds indicate gold potential.
Site 2. **Morgan Creek/state Route 350** crossing near **Big Spring.** Vicinity finds indicate gold potential.
Site 3. **Beal Creek/FMR 821** crossing near **Big Spring.** Vicinity finds indicate gold potential.

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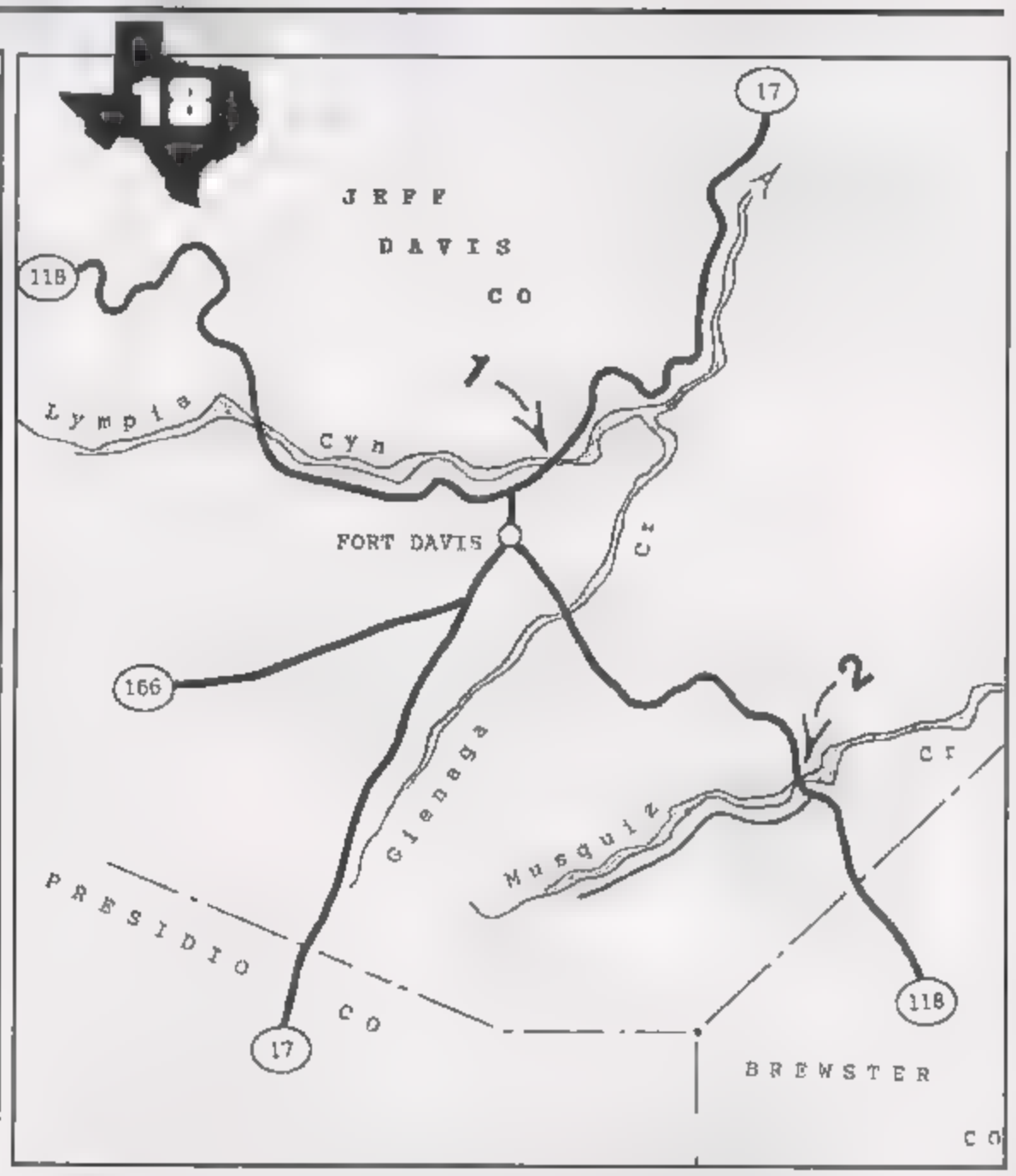


HUDSPETH COUNTY (MAP TX17)

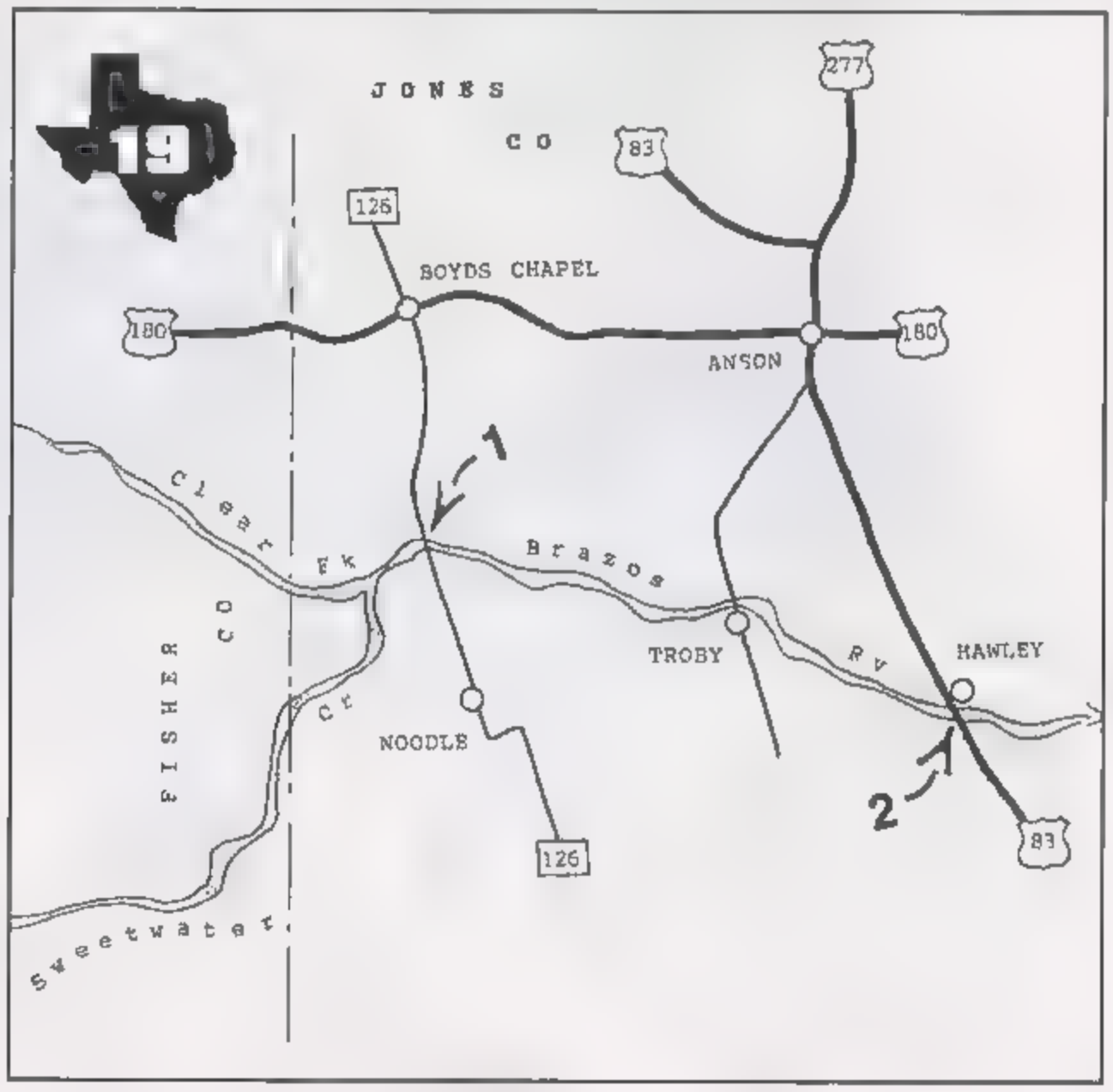
Site 1. **Red Light Draw/County Road** crossing near **Sierra Blanca.** Vicinity finds include agate, amethyst, carnelian, jasper, and silicified wood

Site 2. **Red Light Draw/County Road** crossing near **Sierra Blanca.** Vicinity finds include agate, amethyst, carnelian, epidote, and silicified wood

JEFF DAVIS COUNTY (MAP TX18)

Site 1. **Lympia Canyon/state Route 17** crossing near **Fort Davis.** Vicinity finds include chalcedony and jasper

Site 2. **Musquiz Creek/state Route 118** crossing near **Fort Davis.** Vicinity finds indicate moonstone potential



JONES COUNTY (MAP TX19)

Site 1. **Brazos River/FM R 126** crossing near **Boyds Chapel.** Vicinity finds indicate malachite potential

Site 2. **Brazos River/U.S. Highway 83** crossing near **Hawley.** Vicinity finds indicate malachite potential.

SEA MONSTERS in the DESERT

Fossil Hunting in Morocco's Oulad Abdoun Basin

Story and Photos by Bob Farrar

This Cretaceous turtle fossil from the Oulad Abdoun Basin measuring about 3 feet across is fairly complete, including the shell, as well as other skeletal parts.

In the past, I have written about some of the many fabulous mineral and fossil localities of Morocco that I have had the privilege of visiting. Among these was the town of Erfoud, which I referred to in a November 2004 *Rock & Gem* article as the "Fossil Capital of Morocco." In my opinion, that distinction still holds. However, as I learned on a September 2004 visit, there is another place that comes darn close: Khouribga, in the heart of Morocco's vast phosphate region.

ALISA AARONSON PHOTO

At about 8 feet, this mosasaur skeleton is one of the smaller specimens found at Khouribga

The formations around Khouribga are incredibly rich in fossils of marine vertebrates, including some that are perhaps best described as sea monsters. All too often, I have seen Khouribga fossils at shows with labels that say only "Shark Tooth, Morocco." Learning about them through my travels and through library research has been an enriching experience. My visit to Khouribga was arranged by tour organizer Sara Mount, with local guidance by Moroccan tour guide and fossil dealer Alisa Aaronson. This was the third time I had been to Morocco, but the country has such a diverse array of minerals and fossils that there is always more to see.

The phosphate deposits of Morocco are enormous. By some estimates, the country has as much as 75 percent of the world's phosphate reserves. When you think about how many other phosphate deposits there are in the world, and how large some of them are (those in North Carolina and Florida, for example), you get an idea of just how vast Morocco's are. Morocco's phosphate reserves are estimated in the range of several tens of billions of tons. The mining industry has an annual production in the tens of millions of tons of phosphate rock. Generally, the rock is mined in open-pit operations. It is transported from the pits to processing facilities by miles-long conveyor belts. Then it is processed into phosphoric acid and other products that are usually sent by rail to the coast for expor..

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BOB FARRAR PHOTO

Teeth of Cladus obliquus, such as this nearly 4-inch specimen, are the largest shark teeth found at Khouribga.

BOB FARRAR PHOTO

White quartz geodes from Khouribga often contain tiny, doubly terminated crystals.

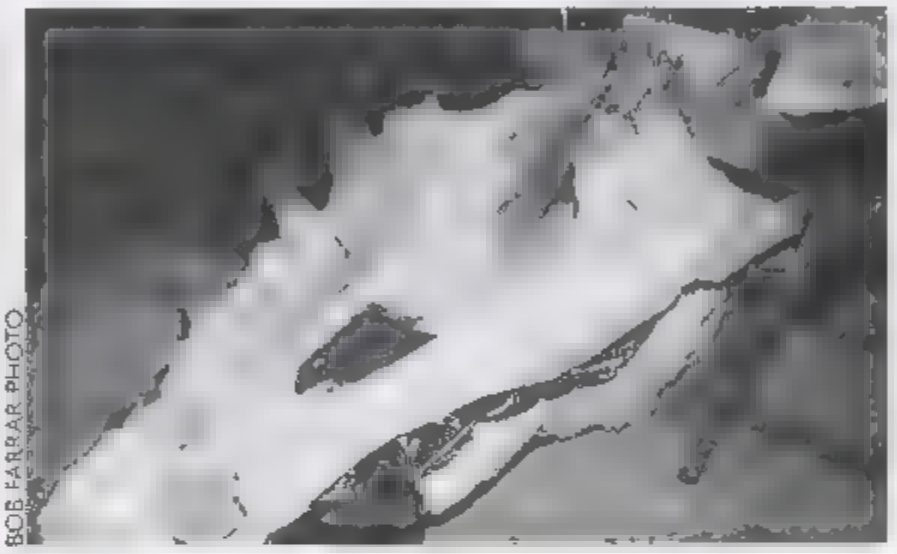
Sea Monsters in the Desert *from page 41*

There are three major phosphate localities in Morocco, with an additional one in the territory of the Western Sahara, a region occupied by Morocco since 1975. The largest and most important of these is the Oulad Abdoun Basin, located about 75 miles south of the capital city of Rabat. Centered around the towns of Khouribga and Oued Zem, it covers over 3,000 square miles and is known as the Phosphate Plateau. The Ganntour Basin, located just north of Marrakech, covers some 600 square miles. The Meskala Basin, covering about 360 square miles, is between Marrakech and the coastal city of Essaouira. In the Western Sahara, the Oued Eddahab Basin, or Boucraa Basin, is near the town of Laayoune. Most of the mining takes place in the Oulad Abdoun Basin, and it is from there that most of the Moroccan phosphate deposit fossils on the market come.

The phosphate-bearing formations of Morocco typically consist of sedimentary rocks originally deposited in warm, shallow seas near ancient shorelines. They include limestones, clays, marls, and siliceous rocks. Some layers are soft and crumbly, while others are well lithified (hard). The phosphate generally occurs as microscopic grains of carbonate fluorapatite, $Ca_5(PO_4,CO_3)_3F$. Mineral collectors will not find interesting crystals of phosphate minerals, though in some areas one can find white quartz geodes up to several inches across. They often contain tiny, loose, doubly terminated quartz crystals. Some of these geodes remind me of ones I have collected in Tennessee.

The formations of the Oulad Abdoun Basin range in age from the late Cretaceous Period, about 65 million years old, through the Paleocene Epoch, 54 million to 65 million years old, to the middle Eocene Epoch, about 45 million years old. In the literature, however, one often sees the ages of fossils referred to in terms of the stages within these periods or epochs. In the Oulad Abdoun formations, the following stages are represented: Maastrichtian (latest Cretaceous), Montian (middle Paleocene), Thanetian (late Paleocene), Ypresian (earliest Eocene), and Lutetian (early to middle Eocene). The series is not continuous; there are gaps or unconformities in it.

Of all the "sea monsters" found at Khouribga, mosasaurs are perhaps the most important and most impressive. Mosasaurs were marine reptiles that lived during the Cretaceous period. They had four flippers, a long, flattened tail used for swimming, short necks, and large heads. Some species reached lengths of over 30 feet. They also had lots of teeth, six rows of them. There was one row of teeth on each of two lower and upper jaws, and two rows on the palate. Old teeth were shed and replaced with larger teeth as the animal grew. Mosasaurs are thought to be closely related to snakes and, like snakes, could disarticulate their jaws to swallow large prey. Mosasaurs became extinct at the end of the Cretaceous period, at the same time as the dinosaurs.



BOB FARRAR PHOTO

This large mosasaur skull, held upside down for preparation, shows the rows of teeth on the upper jaws as well as on the palate.

The most common mosasaur found at Khouribga is usually called Mosasaurus anceps (M. anceps). You also see it referred to as Mosasaurus cf. anceps. The designation "cf." means the specimen is most likely anceps, but there is not enough information, perhaps only a single tooth, for a positive identification. Shed teeth of M. anceps are common at Khouribga, and can be up to 3 inches long. The root was not shed along with the crown, so teeth with roots are much more rare, being fossilized only when an animal died. Several other species of mosasaurs have been found at Khouribga, including Globidens aegyptiacus, with blunt teeth thought to have been used for crushing shells of mollusks.

Another Khouribga sea monster is the plesiosaur Plesiosaurus mauritanicus. Plesiosaurs were also marine reptiles. They had rounded bodies, short tails, four flippers, long necks, and small heads with sharp teeth. A plesiosaur is sometimes described as looking like a snake threaded through a turtle (but without the shell). Some people theorize that the Loch Ness Monster is a plesiosaur. Plesiosaur teeth from Khouribga are slender and perhaps 2 inches long. They are much more rare than mosasaur teeth. Plesiosaurs also became extinct at the end of the Cretaceous.

A more familiar, but still formidable, reptile found at Khouribga is the crocodile. Crocodile fossils are found in the Cretaceous formations and Paleocene and Eocene layers at Khouribga. Some species from Khouribga had long, slender snouts with small teeth adapted for catching fish, similar to the modern gavial. Other species had broader snouts, more like an alligator. Overall, crocodiles have not changed greatly. Teeth are the most common fossils, but skin plates, skulls, and whole skeletons are also found. Other marine reptiles found at Khouribga include turtles and sea snakes. A variety of turtles are found in all layers. Some are quite large, with shells several feet long and skulls perhaps 6 inches across. Fossil turtles from Khouribga are not that different from their modern relatives. Vertebrae of the Eocene sea snake Palaeophis are also common.

By far, the most abundant vertebrate fossils of Khouribga, and the most familiar to collectors, are shark teeth. Thousands upon thousands of them find their way to the fossil market. A great diversity of shark teeth is found in formations of all ages at Khouribga. It would seem that the ancient seas of Morocco were teeming with sharks, and they probably were. However, it must be remembered that sharks constantly shed old teeth and replace them with new ones. A single shark may shed thousands of teeth in its lifetime. This helps explain the abundance. The vast majority of shark teeth are found singly, much more rare is an "associated dentition," a group of teeth all from the same shark that was deposited when the shark died.

The largest, and perhaps most familiar, shark teeth from Khouribga are those of Otodus obliquus, formerly known as Lamna obliqua, of the Eocene epoch. These teeth are broadly triangular, with straight, not serrated, edges and a small cusp on each side of the base, and get up to 4 inches long. While not as exotic as a mosasaur, perhaps, a shark big enough to have 4-inch teeth is a sea monster that I would not want to meet.

One of the most sought-after shark teeth of Khouribga is from Paleocarcharodon orientalis, previously called Carcharodon landanensis. Teeth of this species are triangular, with serrated edges, get up to perhaps 2 inches long, and are much rarer than those of Otodus. The long, slender teeth of Odontaspis are very common. A great variety of other species of shark teeth are found at Khouribga, and it is far beyond the scope of this article to cover all of them.

continued on next page

Sea Monsters in the Desert *from page 43*

Fossils of many types of bony fish (as opposed to sharks and rays, which have skeletons of cartilage) are found in the phosphate beds of Morocco. Generally, teeth and mouth plates are found, though bones are also found. The teeth of the Cretaceous Enchodus, which is thought to be related to salmon, are common. They get up to perhaps 2 inches long. A variety of other strange teeth can also be found.

Perhaps the rarest and most special fossils found at Khouribga are those of land mammals of the early Eocene. These turn up in the marine layers that were closest to shore. All land mammals found in the major phosphate beds come from an area in the northeastern part of the Oulad Abdoun Basin known as Grand Daoui. Among the finds at this locality are teeth and jaws of the earliest known elephant, Phosphatherium escuilliei. It was a surprisingly small animal, weighing between perhaps 10 and 15 kg (22 to 33 pounds). Teeth of several other types of land mammals and fossils of marine birds have also been found.

Khouribga is one of the most prosperous cities in Morocco, thanks to the phosphate industry. It is not a popular tourist destination, but there is a nice hotel, which appears to cater mostly to men who come on working visits to the phosphate mines and plants. We stayed there for two nights, and found it quite nice, although they had recently put in new toilets (Western style, thankfully) and most of them did not work quite right. There was even a display of fossils in the lobby.

Our first morning in Khouribga, we headed out to try our luck finding some sea monsters. The road out of town is paved, and very good. At first glance, the countryside around Khouribga looks pretty barren. There is very little vegetation, just enough to support a few camels and goats. In the distance, we could see what looked like mountains. Closer up, it became clear that these were the tailings piles from the phosphate plants, some of them hundreds of feet high. We also began to see the conveyor belts transporting phosphate rock. Soon, we turned off the paved road onto a dirt track and stopped to meet Kebir, Aissa's friend and a local fossil dealer. He guided us to an abandoned phosphate pit where we would have the chance to do some collecting.

The pit was not large as phosphate mines go, perhaps a few hundred yards long by a couple hundred yards wide, and 20 or 30 feet deep. We had barely stepped out of the car when we started seeing shark teeth. They were everywhere. Most were small, and many were broken, but we quickly found some nice specimens just lying about. There was a soft Eocene layer partway up the side of the pit in which local collectors had been digging. We were able to dig teeth out of this layer ourselves. There were also teeth embedded in boulders of harder rock. These required a hammer and chisel, which I had brought, to collect. It was hard to remove teeth from the hard rock without breaking them, but I was able to get some specimens in matrix, which I like just as well. Most appeared to be Odontaspis, but a few Otodus and others were found, as well.

BOB FARRAR PHOTO

These turtle and crocodile skulls from Khouribga are not very different from those of their modern counterparts.

Kebir found two turtle fossils embedded in the floor of the pit. One appeared to be a skull and the other a broken-up shell. The rock in the floor of the pit was quite hard, and it would take some time to recover these turtles. Kebir would have to do that at a later time.

A mineral collector would not have been totally bored at this site; there were lots of geodes to be had. Most were perhaps 4 to 6 inches across. I cracked one, and it was full of hundreds of tiny, doubly terminated quartz crystals. To some people, geodes look better sawed than cracked, but I was not going to haul a heavy rock all the way back from Morocco without knowing if it was any good.

I could have kept at it all day, but the sun was fierce, even though it was September. We were really going through the bottled water we had brought. Soon, most of our group was sitting in the shade under an overhanging wall of the pit. There we had a picnic lunch consisting of fresh bread from a local market, canned tuna, and bananas. We then decided to call it a day for collecting, and head over to see Kebir's collections and those of some of the other local dealers. The biggest sea monster fossil that was found day was a 1½-inch Otodus tooth.

Kebir's house and those of the other dealers we saw were nondescript little mud-brick buildings like a million others in Morocco. If I were just driving through, I would never have found them. Aissa, however, is friends with many of the dealers and knows how to get in touch with them. While Kebir's house is nothing special on the outside, inside he has a treasure trove of fossils: mosasaur skulls, crocodiles, turtles, plesiosaur teeth, and more shark teeth than you could count. The same was true of the other dealers, one of whom also had a pair of jaws of the elephant Phosphatherium. All had amazing selections of fossils.

The bigger dealers do not collect all of their material themselves, they buy much of it from local diggers and miners. Workers at the phosphate mines are allowed to bring out material if they can grab it quickly, however, the mine will not suspend operations to allow the extraction of something big, like the skeleton of a mosasaur. These often just get bulldozed. I don't even want to think about how many valuable fossils get ground up for phosphate.

Besides Kebir and the other big dealers, there are many small-time fossil diggers and dealers. They may sell their material to the bigger dealers, or when they get the chance, to visitors like us. They seemed to appear out of nowhere with boxes of fossils to sell. Some of them had pretty good material, some of which I bought for a good price.

One shortcoming of the fossil business of Khouribga is that material generally does not come with specific information about locality or age. Diggers and dealers usually do not keep information about which hole or which layer something came from. The same formations generally underlie the whole area, so many of the same fossils come from a wide area. Usually, "Khouribga," "Oued Zem," or "Oulad Abdoun Basin" are about as good as you get, and refer to basically the same place. If you see a shark tooth just labeled "Morocco," there is a good chance that this is where it came from, though shark teeth are found at other localities in the country.

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Sea Monsters *from page 44*

Determining the age of a specimen may require identifying it and matching it to lists of known species from a given period. For example, mosasaurs and plesiosaurs became extinct at the end of the Cretaceous period, which is the oldest period represented at Khouribga. Therefore, any mosasaur or plesiosaur tooth from Khouribga can reliably be dated as Cretaceous. Similar determinations can be made for many other fossils.

Another flaw of the fossil trade all over Morocco is fake fossils. Trilobites, for example, may be casts molded from real specimens or sculptures of imaginary species. Dealers may take a broken or partial specimen and 'restore' the rest of it, sometimes most of it. At Khouribga, it is common to see fossils that have been restored to some extent, sometimes excessively. For example, preparers may replace the root broken off shark teeth with a plaster material covered with ground up shark teeth. They used to use a flour paste for this purpose, but bugs would get into it, and shark teeth with worm holes would not sell well. It can be difficult to tell if a shark tooth has been restored with plaster.

Among the most commonly faked fossils are mosasaur jaws and teeth with roots. Actual mosasaur tooth roots are porous, like bone. In the fakes, there will generally be an amorphous brown layer of plaster between the crown and the root. The whole thing may be embedded in a fake piece of matrix. To make a fake jaw, they may embed several real crowns and a piece of bone in a fake matrix. One clue that a piece is a fake is the size of the bone. The root on a mosasaur tooth is 2 or 3 times as long as the crown. Thus, if you see 1-inch-long crowns on a 1-inch-thick bone, be suspicious because the bone is not thick enough to contain the roots that would have gone along with those crowns. You can also often see the brown plaster layer on these.

Also commonly faked are associated dentitions of Otodus. In this case, several real teeth are embedded in a fake matrix. All the teeth will be laid out nicely on top of the rock. In a real associated dentition, the teeth can be jumbled up at all angles. Be suspicious if it looks too perfect.

The phosphate beds of Morocco are a source of great fossils for beginning and advanced collectors alike. The sheer abundance of the more common species ensures that specimens can be had by almost anyone for an affordable price. The rarer specimens give the advanced collector something to aspire to own. Given the vastness of Morocco's phosphate deposits and the well-established trade in fossils, the parade of sea monsters making their way onto the fossil market will not likely end anytime soon.

ROCK & GEM

ANHYDRITE AND GYPSUM

Gypsum $CaSO_4 \cdot 2(H_2O)$, is an evaporite mineral that forms in the sediments of ancient lake- and seabeds. It is found in mining areas all over the world and in the walls of your house! The white gypsum wallboard used in homes and commercial buildings is fire resistant and rigid, and will last a lifetime if it doesn't get wet. According to the U.S. Geological Society, a typical new American home contains more than 7 metric tons of gypsum in its walls and foundation. Gypsum is also used as a soil conditioner to reduce surface crusting, making it easier for seedlings to break through into the sunshine.

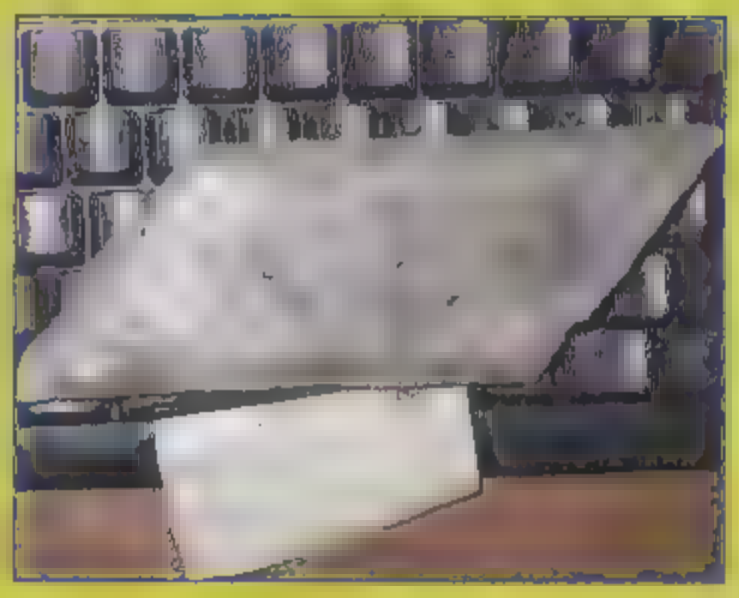
Gypsum is so soft Frederick Mohs made it No. 2 on his scale of hardness. Clear crystals of gypsum are called selenite, alluding to the pearly moonlight sheen that may be displayed on cleavage faces. Large, clear, trapezoidal crystals of selenite gypsum are found in the province of Teruel, Spain. Bladed bars of gypsum crystals are found in Mexico, and at St. David, Arizona, and are sold as "desert roses" in the trading posts and tourist shops.

At Camp Verde, Arizona, pseudomorphas of gypsum after glauberite are abundant. Glauberite crystals originally formed in the ancient lakebed and got released in fine-grained mud, which then dried out and got hard as rock. The water-soluble glauberite crystals were then dissolved, leaving a mold to be filled with other minerals, notably gypsum, calcite and aragonite. Today, the soil is eroded by wind and rain, and the casts of glauberite crystals are washed to the surface.

Camp Verde is a great place to go for a family field trip. It is a friendly little town, full of visitors, with a great climate and lots of cool things to see. Just stop in for breakfast and make some new friends. If you tell the waitress you are interested, maybe she will know someone who will tell you where to go look for cool rocks. The pseudomorphs are found in many of the washes and gullies that surround the town.

Anhydrite

Selenite after Glauberite



Selenite

Anhydrite, $CaSO_4$, occurs where gypsum was formed and later dried out. When the water was lost, the gypsum became anhydrite. Sometimes, the reduction in volume caused by the water loss created caves where mineral crystals might grow. Viola! The perfect conditions are created to make some of the largest and most perfect mineral crystals in the world. At Naica, Mexico, miners discovered selenite gypsum crystals that were more than 10 meters (about 30 feet) long and 1.5 meter in diameter.

Since gypsum is a common mineral, you would think anhydrite would be common, as well. This is true for the massive form, but for some reason, anhydrite rarely forms nice crystals.

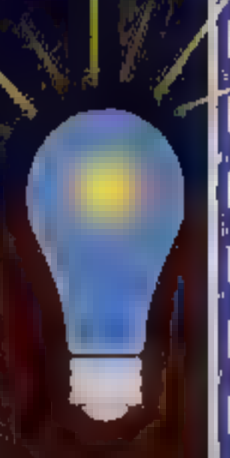
Nice anhydrite specimens are found in Naica and may be dusted with tiny pyrites and other sulfide minerals. Mining operations started at Naica in the late 1800s and still continue today. The Naica ore deposit is a skarn, which forms when limestone is altered by heat and pressure and becomes garnet and/or pyroxene. Naica's skarn formed within a limestone body split by large faults. Water flowed through these faults at about 136 degrees F (58 degrees Celsius) at a pressure of 426 psi (30 Kg/cm^2). This water contained dissolved calcium, carbonates and metals that formed crystals of selenite, anhydrite, sphalerite, and galena.

Good information and amazing pictures of gigantic selenite gypsum crystals are found on the Web site of The Center for Advanced Studies of Mineral Resources, a Spanish geological training organization (www.cesmat.asso.fr/English/naica.htm).

KIDS

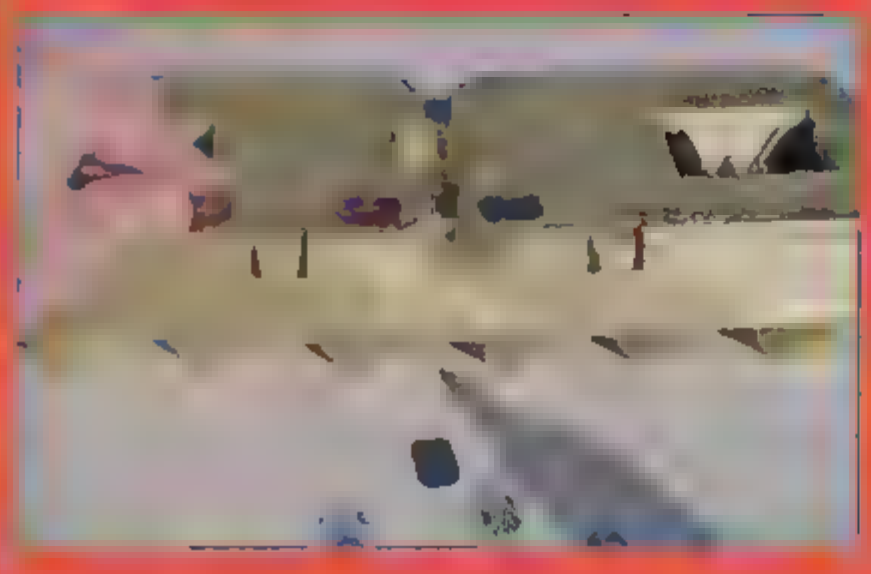
TREASURE BOX PROJECT

Rock & Gem Kids Quiz



The *Rock & Gem* Kids Quiz contest is open to U.S. residents age 18 and younger. All these questions can be answered by carefully reading this column. Write your answers neatly on a postcard or 4X5 card and mail to *Rock & Gem* Kids Quiz, P.O. Box 6925, Ventura, CA 93006-9899. Valid entries received by Mar. 31, 2006 will be entered in a drawing from which five winners will be chosen. Valid entries must be the entrant's own work and must include the correct answers, the entrant's name, age and address, and the signature of a parent or guardian. Prizes are generously provided by the Arizona Mineral and Mining Museum Foundation.

1. Gypsum is an _____ mineral that forms in the sediments of ancient lakebeds.
2. Anhydrite is formed when gypsum loses all its _____.
3. At _____, Mexico, miners found gypsum crystals more than 10 meters long.
4. Name two elements that gypsum and anhydrite have in common.
5. At Camp Verde, Arizona, selenite crystals formed pseudomorphs after _____.



DIAMONDS

Gems of Industry and Fashion

Story by Kenneth H. Rohn

Without a doubt, diamond is the most valuable mineral on the face of the earth. As a matter of fact, I would venture to say that diamonds take precedence even over gold, another one of mankind's most coveted minerals.

Diamond is not only highly valued as a beautiful and expensive gemstone, but the industries of the world have depended upon it since its discovery for cutting, shaping, grinding and drilling other super-hard substances, including diamond itself. When diamond is used for wire-drawing dies, thousands of feet of steel wire can be drawn to a specific size before the die has to be replaced. In lapidary, diamonds and diamond products are use extensively in the preparation of gems.

The big news today is the fact that productive diamond pipes have been discovered quite recently in southern Wyoming and adjacent northern Colorado, practically on the border of these states. There have also been numerous discoveries of in situ diamonds in the provinces of Canada. Gem-quality stones have been recovered in several of these locations. The future of diamond production in the western United States and Canada looks bright indeed.

One puzzling phenomenon occurred in the California gold fields during the 1849 rush. Diamonds were discovered in gold pan concentrates. It has always been a mystery how alluvial diamonds were found in substantial numbers in California during the gold rush. Some effort was made to locate them in situ, with negative results, their origin was never discovered in that state. One theory is that the pipes that brought them to the surface have eroded away and become buried with overburden over vast time periods. Another is that the pipes never actually existed, the stones were transported by rivers that originated far to the north in Canada and have long since vanished. The vast new deposits of high-grade diamonds—kimberlite pipes hidden by small, round lakes as far north as the Arctic Circle recently discovered by our northern neighbors, have more or less substantiated this assumption. For a great read, see Steve Voynick's article "Diamonds of the Northwest Territories," in the September 2004 *Rock & Gem*.

With an atomic weight of 12.0111 and a specific gravity of 3.5, diamond is pure—or close to pure—carbon. It crystallizes in the isometric, quite often octahedron, rarely cubic, and sometimes dodecahedral systems. It can be translucent to transparent, and has a conchoidal (having curved surfaces that are somewhat similar to the surface of a clam shell) fracture.

Carbon, a nonmetallic element, can be traced to all organic matter. Everything on Earth, animal, mineral and vegetable, contains carbon. Our biological process of eating a meal causes oxidation of the carbon in our food, giving us energy. Everything and anything we can think of contains carbon, the

clothes we wear, the fuel we burn in our cars, the coal used to produce electricity, etc.

The chemistry of graphite (pencil lead) and diamond are exactly the same, carbon. Yet graphite has a Mohs hardness of only 1 to 2, as compared to its super-hard relative at 10. Graphite has a low specific gravity of 1.9 to 2.3, much lower than that of diamond. Graphite was formed entirely differently from diamond in every respect, yet it is a kissing cousin. Graphite is metamorphosed from a carbonaceous substance found in sedimentary rocks.

By looking at a raw diamond, one would never suspect that it could be transformed into a beautiful faceted gemstone. I have seven uncut diamonds from the Congo. They're from 1 carat to 4 carats in size. Only one has the rough outlines of an octahedron. One is close to a cubic shape, and the others are indistinct granules. They all have a glistening, metallic luster in natural light. When held under my long-wave ultraviolet light, two of the stones fluoresce a dazzling cobalt blue, one fluoresces a pretty yellow, and the others appear muddy brown. Under natural light, they are off-white, brown, and light yellow, and not very impressive. Two of them show promise as finished faceted gems of perhaps a half-carat. The others have flaws and inclusions. None even remotely resemble a faceted diamond.

If these stones were casually seen resting in a gravel bed or on a roadside, they'd look no different than the myriad other pebbles, and wouldn't get a second glance. But they are pretty and will make interesting conversation pieces while on display in my specimen cabinet.

Diamond has a perfect cleavage in four directions, which aids greatly in the cutting and faceting of gemstones. It's very brittle and it shatters almost as readily as glass. There has been some mention in history of men destroying valuable diamonds by hitting them with a hammer in an attempt to identify them, because they thought diamonds were indestructible.

Diamonds can be water clear (white), yellow, brown, orange, red, champagne, blue, black, gray, and green, plus various shades of these colors. Blue, green and red are the rarest and the most valuable as faceted gemstones. The Hope Diamond is a beautiful blue stone.

Generally, black diamonds are seldom seen as a faceted gem. The vast majority of these are used in industry, they are heavily flawed and not suitable for gemstones. Other forms of diamond are carbonado and bort, which are aggregates, composed of tiny, often microscopic, crystals. These are generally used in a reduced form as cutting, grinding, sanding and polishing compounds.

Diamonds are found in equant form, but nature being what it is, they are usually quite far from perfect. Most have slightly curved faces, and some are found as rounded, irregular shapes and grains. Microscopic diamonds have been known to exist for a long time in areas where no large stones have ever been discovered. Diamond is adamantine, with a most unusual greasy luster, and some stones are highly fluorescent. One of the best field marks is that greasy feel. Another is the high, somewhat silvery, metallic luster.

This majestic gemstone has, for a long time, been mined in sedimentary placer deposits at various places in the world, although the majority of them today are mined in kimberlite pipes (peridotite in plutonic rocks). These pipes tend to be trumpet-shaped as they near the surface, and narrower deeper in the ground. Not every kimberlite pipe contains diamonds. Strangely, many pipes are quite barren.

continued on next page

KENNETH H. ROHN PHOTO

These core samples were taken during recent diamond drilling exploration in the United States and Ontario, Canada.

KENNETH H. ROHN PHOTO

Natural diamonds (left) rest in a gold pan with kimberlite concentrates. To the untrained eye, they look like ordinary pebbles.

Garnet is one of the indicator minerals associated with diamonds. When garnets are discovered, their trail is followed up by test sampling to the heaviest concentration. Next, prospectors test for diamonds.

Diamonds were first discovered in India at some unknown date. The discovery of diamonds in South Africa came about in 1867. This country ranks as the world's largest producer, with mines that are growing ever deeper. In fact, they are so deep and hot they have to be cooled down with a steady flow of water and volumes of fresh air pumped from the surface in order to make working conditions barely tolerable. Today, studies are being conducted to determine just how deep a miner can work and tolerate the intense, often overpowering heat. In order to survive these conditions, underground diamond miners work in shorter shifts and take frequent breaks.

Diamond, at number 10 on the Mohs Scale of Hardness, is the hardest of native elements. The scale was devised by Frederick Mohs (1773-1839), a German mineralogist, and with the exception of diamonds, consists of representative minerals that are relatively easy to come by. Diamond, being the hardest, cannot be scratched by any other mineral on the scale; however, each mineral can scratch another with the same or a lower number. The scale is not precise and a bit arbitrary. For instance, diamond is at least four times harder than corundum (sapphire/ruby) at number 9, while corundum is less than two times as hard as topaz, number 8 on the scale.

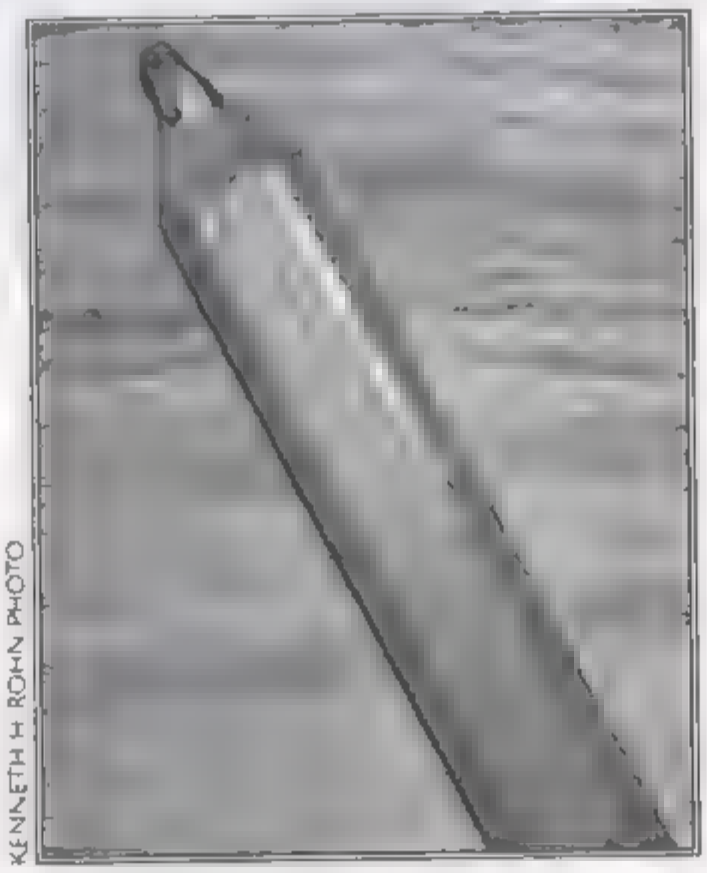
Mohs hardness test kits can be obtained at any scientific supply house. A streak plate, which normally comes in handy for identifying minerals in the field, will not help you identify a diamond. It's too hard to be streak tested. Emery cloth has a Mohs hardness of 8 to 9. If you think you've discovered a diamond, rubbing a scrap of emery cloth on one surface would give you a clue to its identity, that is, if the emery cloth doesn't scratch it.

For a long time, it was thought that diamonds were a product of volcanoes. They were believed to have formed in the fiery bowels of the Earth in molten lava flows. They do form under extremely high heat, presumably up to 3,000 degrees Celsius, and under thousands of pounds of pressure. They have gradually made their way upward under extreme pressure. It staggers the imagination to try to comprehend just how long this transition has taken.

Diamonds were discovered in Brazil in the early 1700s, although the vast majority are black, or industrial, stones. A kimberlite pipe was discovered in the United States quite by accident in 1906, near the town of Murfreesboro, Arkansas. John Huddleston, a local farmer, had heard previous reports about the possibility of diamonds in the area. While plowing his field, he noticed two unusually shiny pebbles in a furrow. Upon careful examination by experts, they were verified as gem-quality diamonds. Huddleston's land encompassed part of the Prairie Creek outcrop near Murfreesboro. The farm changed hands several times over the years, and a portion of the original Huddleston farm is now Crater of Diamonds State Park.

KENNETH H ROHN PHOTO

Charcoal, like diamond, is pure carbon, but unlike diamond, its hardness is much lower than Mohs 10.



KENNETH H ROHN PHOTO

Graphite, a form of pure carbon, combined with clay is used in carpenters' pencils.

At Crater of Diamonds State Park, for a nominal fee, you can search for diamonds to your heart's content. The huge field that comprises the mine is plowed regularly, which adds tremendously to your chances of spotting one of those gleaming gemstones. Dirt and mud do not adhere to these stones, so that's one clue to their identity.

There are several methods of searching. Some people simply walk facing the sun. If they are lucky enough and pay close attention to light reflections, they just might pick up a diamond by following down the beam of light. Others take shovel and screen and dig for them. I've tried both of the above methods, with no success. If it has rained recently, be forewarned: mud may not stick to diamonds, but it certainly does to our shoes. You can find yourself walking around with very heavy footwear.

An acquaintance of mine used what he called a diamond finding rod, a piece of metal about 3 feet long. He didn't find any diamonds while I was with him, but he swore it worked, acting similar to a witching wand. I was skeptical for a long time about this so-called phenomenon, but when we built our new house in the country, I did a little clandestine experimenting. A lady friend of my wife's and

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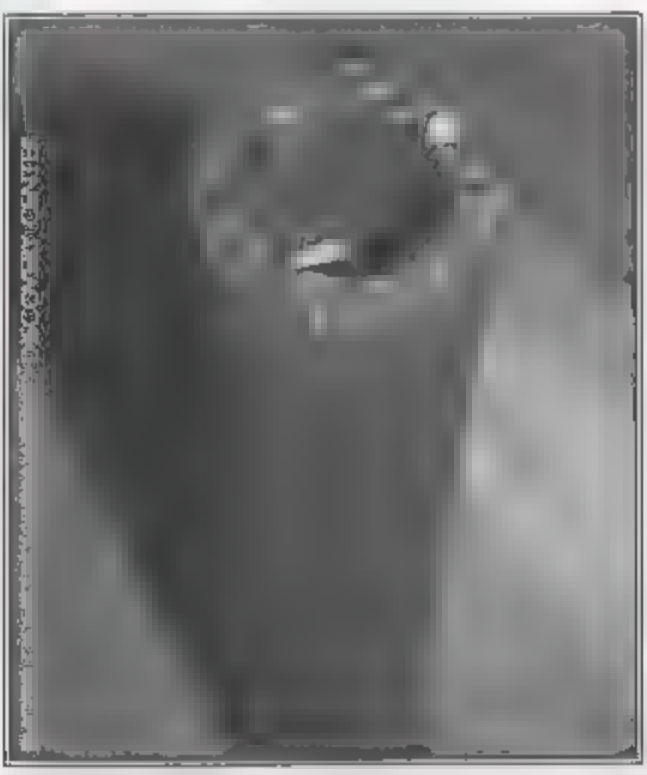
Diamonds *from page 64*

mine was well-known for her skill with a wand. She took a Y-shaped willow sapling and walked around our lot. When the wand very dramatically pointed to the ground, she put in a stake. This was where I should have the well drilled, I was told. Later, when the driller arrived, He took out a witching wand and walked the property. (Before he came, I pulled the stake and took a bearing on the location.) Lo and behold, a few minutes later, he stopped not more than 3 feet from our friend's marker. Our well was dug at that very location. So there's got to be something to say about witching for diamonds - that is, if you have the gift.



Pieces of diamond protrude from the edges of a core drill bit, used to locate new iron ore bodies in Northern Minnesota.

Diamonds have been discovered in several states, including New York, Indiana, Illinois, Michigan, Arkansas, Alabama, Georgia, Tennessee, Wisconsin, North Carolina, South Carolina, Montana, Colorado, Wyoming, Idaho, California, Virginia, and West Virginia. Some have a record of only one or two finds, others have substantially more. The discovery of alluvial diamonds practically ceased when placer mining fell into decline during the early 20th century.

One fantastic example of a single diamond find is the Punch Jones diamond discovered by William P. "Punch" Jones in 1928, in Peterstown, West Virginia. He discovered the stone in a vacant lot while playing horseshoes with his father. It is a green-gray diamond and weighs a hefty 34.46 carats. It is now on exhibit at the U.S. National Museum.

Of course, not all diamonds ever discovered have been reported. Quite possibly, many were unknowingly discarded along with waste material as useless stones clogging up miners' sluices. It would be quite interesting to pan those

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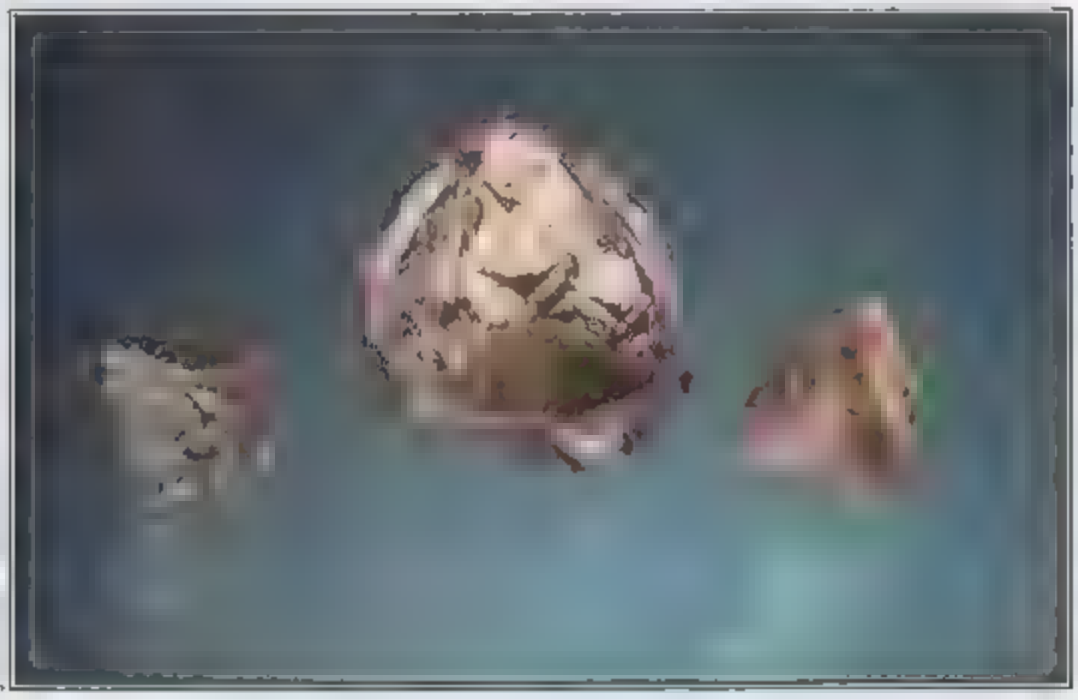

JEFF SCOVIL PHOTO

Most diamonds have slightly curved faces, and some are found as rounded, irregular shapes and grains.

gold bearing streams in an attempt to recover diamonds. I've done a bit of sluicing and panning, and I'll admit it's back-breaking work. I didn't find any diamonds, but I found a few garnets and recovered enough gold to cover the bottom of a tiny vial.

The mining industry has relied heavily upon diamond drilling in the past, particularly during exploration of an ore body of undetermined size and depth. Core drill bits studded with several dozen diamonds are hollow and produce samples of up to 2 inches in diameter. At one time or another, practically every mine throughout the world, underground and surface, has used drill bits bonded with industrial diamonds.

In the Iron Range of northern Minnesota, diamond core drills played an important part in exploring new bodies of natural iron ore. They were also employed in the exploration of precious metals in the North Country south of the Canadian border. These drills, in the hands of a competent operator using moderate pressure on the bit, could bore holes as deep as 400 feet during a normal eight-hour shift.

There are a couple of negative points that should be mentioned about the use of industrial diamonds bonded to drills and saws for any application. First of all, a diamond studded bit or saw would only last a few minutes, quickly burning away from the heat of friction, without the cooling and lubricating action of a constant flow of water on the cutting edge. The other is its brittleness. Any sharp blow can easily shatter a diamond. As long as they are kept cool and heavy impacts are avoided, they'll continue to produce excellent results. Naturally, as hard as they are, diamonds eventually wear away from use.

With the human capacity for innovation and invention, other means of cutting, reducing and shaping have been devised for those hard substances. For example, computer operated and controlled laser beams, tungsten carbide, and super high-pressure liquid cutting machines, plus ultrasonic technology, are giving diamonds some very close competition, but these applications are still rather young. Who's to say what new cutting and reducing technologies are in store for us in the future? Only time will tell.

Due to modern technology, those long-wearing diamond-tipped needles on phonographs are becoming antiquated. I remember the time my wife and I purchased a new stereo phonograph. It had one of the first man-made diamond needles, produced by General Electric. It was an astounding achievement. Scientists had actually unraveled a small portion of the mysteries of the universe and produced a real industrial diamond, one that could not be distinguished from a natural stone, chemically or physically. Today, gem-quality diamonds are being lab produced regularly, with hardly the raise of an eyebrow by the public and at a much lower retail price than the same size natural stone.

Man-made diamonds are practically impossible to distinguish from natural stones. One minor clue is the rather brilliant colors of man-made gemstones, as opposed to the more subdued natural ones. Another is that man-made diamonds are flawless. However, when purchasing an engagement ring or other diamond jewelry, synthesized stones seem to be stigmatized versus natural ones. We have a tendency to suspect them, which is wrong.

So, if it wasn't for the phenomenon deep within the earth that produced diamonds those millions of years ago, we would be much the worse for it. Naturally, we'd improvise and make compromises and eventually accomplish somewhat the achievements that have transpired since the discovery of this marvelous element, but we would most certainly have not progressed as far as we have without it.

LEAD MINING IN MISSOURI

The Nation's Leader in Lead Produced Many Collector Species

Story by Bob Jones

In 1673, missionaries Jacques Marquette and Louis Jolliet, the first Europeans to traverse the length of the Mississippi River, traveled down that long stretch from Canada and claimed the lands along the river for France. As they traveled by what later became known as Missouri, they heard rumors of iron deposits from the Native Americans, but they failed to investigate. As European explorers later entered the area, they heard of lead deposits from the Native Americans, but again, there was no immediate follow-up in spite of the fact that the natives had been using the deposit as a source of pigment and even ornamentation. One reference I read said the Native Americans wore galena crystals for decoration. I find that pretty interesting—and quite burdensome!

Finally, less than 100 years after the missionaries had plied the river, another French priest did investigate these random reports and traveled along the Meremec River to locate the lead deposits. This triggered sporadic exploration, and gradually surface and shallow pit mining commenced on a small scale. From that time on, mining activities continued to expand in that area so that by the latter half of the 19th century serious mining of both iron and lead was being carried on by the French.

BOB JONES PHOTOS/SM THSOMIAN SPECIMEN

This Tri-State cabinet specimen really shows the rich red color of sphalerite

A visit to the area today is mainly of historical interest, as mining in Southeastern Missouri has waned, though some small mines still operate. You can visit Missouri Mines State Historic Site at Park Hills. Mine buildings and equipment are just part of the displays and exhibits you can enjoy. There is even a Hall of Missouri Minerals, which is important for collectors to see, as few examples of the iron and lead minerals mined here can be obtained from dealers today. More recent mining has produced some specimens now seen in museums, but early on this region certainly never produced the volume of collector specimens that came from other Missouri lead-mining areas. In addition, collectors need to appreciate that minerals from Southeastern Missouri have had little impact on collecting.

While Southeastern Missouri mines were the first in the region, they were soon followed and largely overshadowed by more productive deposits in the southwestern part of the state. Lead and zinc mineral deposits in Southwest Missouri had also been worked by Native Americans, so when explorers came into that area, they soon learned of the deposits. Mining began almost immediately in what has since become known as the Tri-State area of Missouri, Oklahoma and Kansas. Luckily, the deposits were shallow and easily worked by the crude methods of the time.

Certainly the Tri-State region has become the best known lead-zinc mining district in America. That this region has produced millions of collectible specimens of galena, calcite, sphalerite, marcasite, and chalcopyrite has contributed

to its popularity among specimen collectors and brought it to the attention of both mineralogists and mineral collectors. For decades, any mineral collector traveling through Southwestern Missouri stopped at local rock shops to obtain specimens from the mines there. In my travels across the United States, I purposely made an effort to pass through this area to obtain specimens. Rock shops across the country grew rich on galena, calcite and sphalerite specimens as collector after collector obtained specimens and made trades with shop owners.

After over a century of high production of lead and zinc metals, as well as superb mineral specimens, the Tri-State mines gradually tapered off and finally closed. Fortunately, the volume of fine mineral specimens was great enough that they grace museums and private collections to this day.

The early success of mining in Southeastern Missouri had encouraged more exploration, and by 1838, mining in the Tri-State area had begun. For convenience, this entire area is often referred to as the Joplin lead and zinc district in the literature, even though the richer ore deposits were centered near Picher, Oklahoma.

Once mining commenced, it continued for nearly 150 years. Near-surface mines were common at first. Gradually, mining at depth commenced, but with problems, water being just one of them. Uses for lead slowly faded, and the price of zinc, which was carrying most of the cost of mining, with lead as a byproduct, began

BOB JONES PHOTO/HOLLOMAN COLLECTION

This remarkable foot-high, delicately colored calcite on dolomite is from Missouri's Viburnum Trend

to slide. As evidence of lead's poisonous effects became known, the demand dropped, with very negative effects on Tri-State mining.

The Tri-State ore deposits are limestone replacement deposits, most of which formed at relatively low temperatures from hydrothermal solutions that invaded the 300 million-year old Mississippian-age dolomitic limestone. As with any limestone replacement ore deposit, different types of ore bodies occurred here. Water followed the natural joints and faults of the rock, slowly dissolving it away to create openings. These became channels for the hydrothermal solutions that ascended into the rock and further dissolved away the limestone.

As the hydrothermal solutions lost heat, they were forced to deposit their mineral load in the form of rich sulfide ores. Limestone naturally has myriad horizontal joints resulting from repeated depositions of the original calcium carbonate. The hydrothermal solutions found ready avenues along these horizontal joints, forming large, stratiform deposits. They proved to be the largest deposits worked for lead and zinc through the years. Solutions also moved vertically, following joints created by weathering and faults formed by tectonic movements. In these vertical openings, chimneys of ore formed.

As in any weathered limestone, large cavities or cavelike chambers developed. Often, these openings eventually collapsed of their own weight and the force of gravity. As solutions flooded the collapsed areas, the broken chunks of limestone became ideal matrix for the growth of crystals, as well as layers of rich ore. These deposits provided vast quantities of wonderfully crystallized specimens of primary lead sulfide galena and zinc sulfide sphalerite, which were found in widely scattered and usually near-surface deposits in the limestone.

Other minor, but very important and abundant, Tri-State collector minerals were brassy chalcopyrite, cockscomb marcasite, and the ever present limestone mineral calcite, usually in dogtooth crystals, but also in other superb forms. Typically, limestone has some silica in it. In the Tri-State deposits, the silica was deposited as hard chert, and many specimens of these collector minerals were recovered on a chert matrix.

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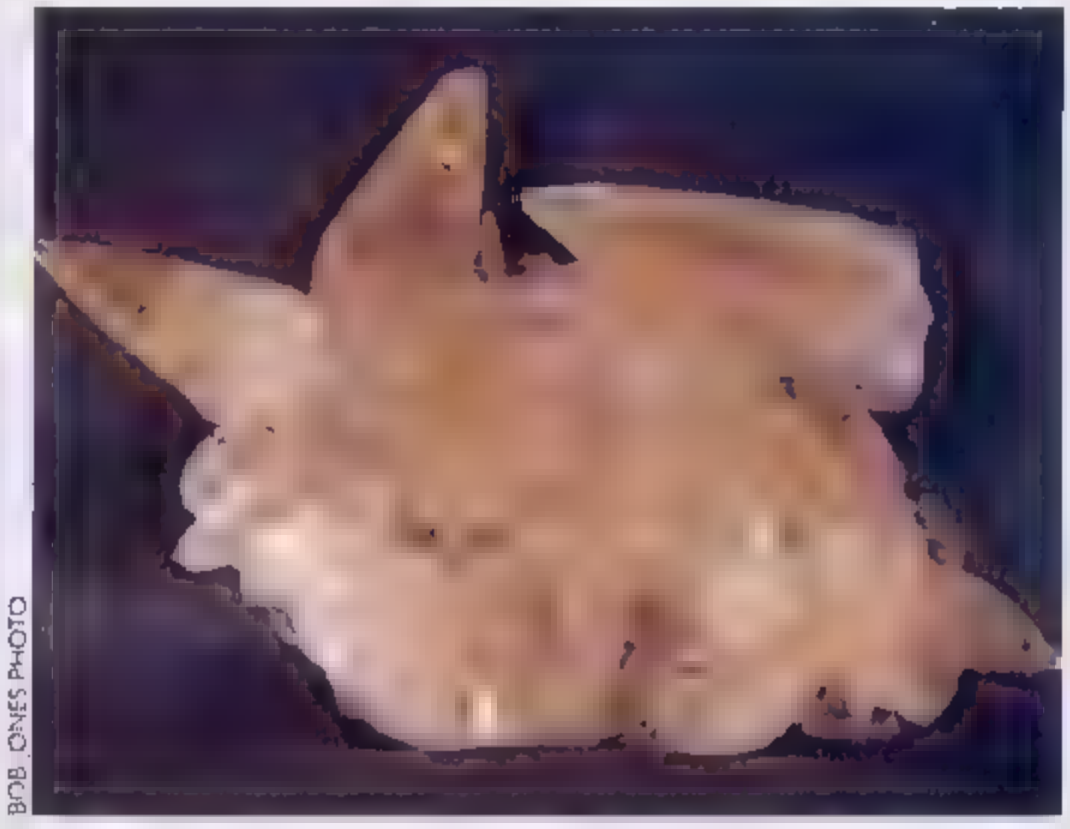
BOB JONES PHOTO/HOLLOMAN COLLECTION

A splash of red hematite gives this Viburnum Trend calcite an unusual feature



BOB JONES PHOTO

Large clusters of dogtooth calcite were very common in the lead mines of Southwest Missouri.

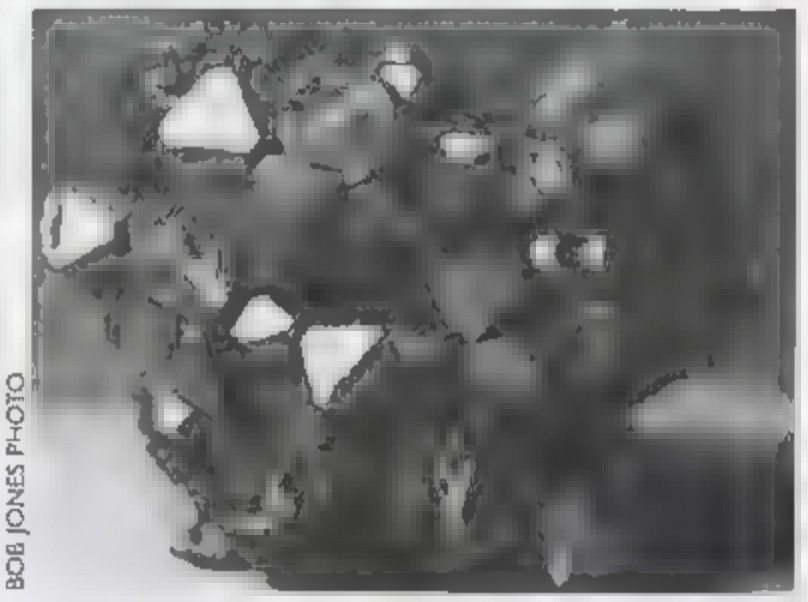
All the early mining ventures reflected the widely scattered and often relatively small nature of these mineral occurrences. Large-scale production had to wait for large investments of capital. Anyone could obtain a royalty lease, which granted mining rights to a 200- by 200-foot patch of ground, with a high probability that ore lay within its boundaries. A 200- by 200-foot mine could never support large production. That such randomly located mining ventures actually produced ore shows just how widespread, abundant, and relatively shallow the deposits were. Most of these mines were no more than 50 feet deep.

The mining created a remarkably vast area nearly covered with small white "chat" piles of discarded waste limestone and chert rock that made the area look like a prairie dog colony. As mining proceeded to depth, more funding was needed to bring these small mines together so ore extraction could continue on a larger scale. Large-scale mining gradually emerged as small mines were incorporated into ever larger, well funded corporations.

It was from the late 1800s to the 1960s that the majority of the fine specimens of the above-mentioned minerals came to grass. Even as the mines shut down, access to closed mines by ex-miners and local collectors continued to add to the wealth of specimens available. This continued until the water table rose enough to inhibit access. There can be no accurate estimate of the number of specimens of galena, sphalerite, marcasite, and calcite that saw the light of day during mining here, but it has to be in the millions.

Collectors traveling through the area could stop at any rock shop, restaurant, or gas station and see locally mined specimens for sale. Bodde Lane's shop and Mr. Rosenberry's place were two of the better-known places. I visited both after mining had ceased in the area and it was mind-boggling to see their yards, front porches, and garages filled with tables of specimens of all sizes and quality. The piles of unsorted specimens scattered about gave me the impression that the supply of galena, sphalerite and calcite from here was infinite. Which immediately brings up the question, "Where did all those specimens go?" You sure don't see huge quantities of Tri-State material for sale at mineral shows these days.

The earliest extensive use of Missouri lead was in the War of 1812,

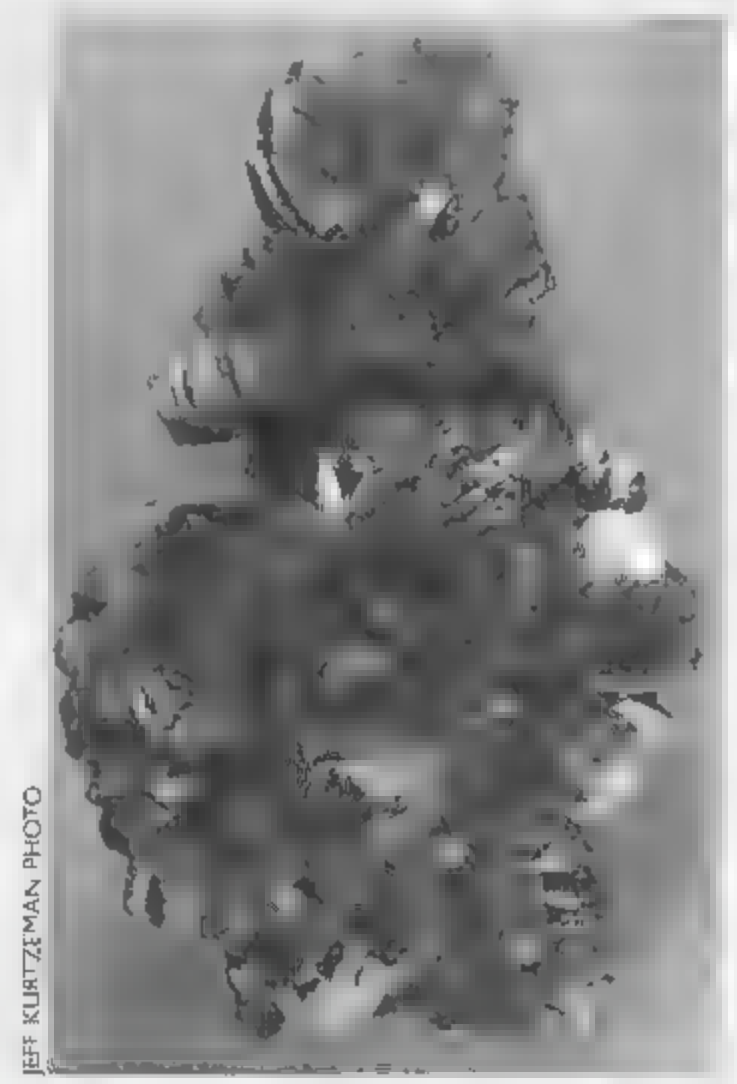


BOB JONES PHOTO

Octahedral galena was not as common in the Tri-State region as simple cubes were

but that lead came from the mines in Southeastern Missouri, which had been developed long before any mining activity in the Tri-State area. By the time the Civil War started, both the Southeast and Tri-State areas were online. As later wars occurred, especially World War I, the Tri-State area really became a significant source of war materials. A huge increase in mining during that time was inevitable, for both lead and zinc were critical metals for the war effort.

World War II brought another huge surge in lead and zinc mining here; lead was used in bullets and the hundreds of thousands of acid batteries needed for the vehicles of war. Zinc was no less critical, since brass shells by the millions were used in artillery.



JEFF KURTZEMAN PHOTO

Cockscomb marcasite is one of the common iron minerals that came from the Tri-State lead mines

Combining zinc with copper to make the alloy brass was first done about 1500 B.C. It has served as an inexpensive substitute for gold and has been very useful as a decorator metal, but its greatest use during wars is in the production of artillery shells. As mining for zinc and lead increased exponentially, the chances of fine mineral specimens being unearthed also increased. Not surprisingly, even after these wars, when production of lead and zinc really fell off, minerals were coming forth because of the activities of dealers, miners and collectors who spent their weekends underground, working out specimens exposed but left behind during mining.

Unfortunately, after World War II and the Korean War, lead and zinc mining really dropped off in this region. By 1960, mining was at a standstill and it has never recovered. This was due in part to richer lead deposits being found along the Viburnum Trend in Central Missouri and in the Elmwood area of eastern Tennessee. More important, there was a dramatic drop in the demand for lead as it was replaced by less hazardous materials in a host of products. While lead and zinc mining in the Tri-State area has left its halcyon days behind, the area and its specimens are historically important as a source of these two elements and huge quantities of collector specimens.

During and shortly after mining in the Tri-State area, specimens of galena, sphalerite, marcasite, and calcite were so common and abundant that they became a hard sell for dealers. It seemed everyone had a nice specimen. But once the source dried up, the huge quantity of specimens extant was slowly absorbed into the mineral collecting community, and today you see only an occasional Tri-State specimen for sale. And more's the pity, as these sulfide specimens are really fine examples.

Galena is the most common lead-bearing mineral on earth. It crystallizes in the isometric or cubic system. The Tri-State galenas were most often found as simple cubes ranging in size from under an inch to several inches on an edge. Less common were octahedral galenas, which suggests they formed from somewhat higher-temperature solutions. Fine octahedrons almost always show small cube faces and, rarely, may have small dodecahedral faces, as well. In many cases, Tri-State galena crystals lack brilliant luster; they more often have dull to velvety lustrous faces.

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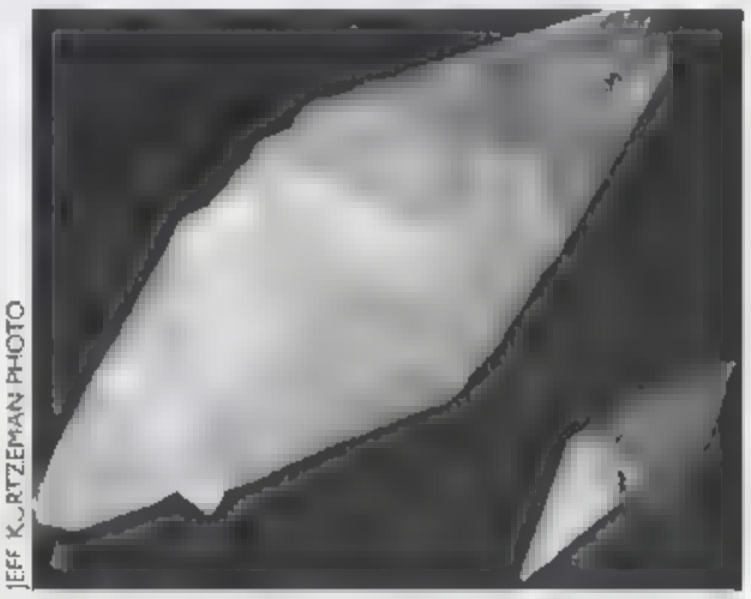
Lead Mining in Missouri *from page 79*

The color of galena is a gray or gun metal gray ranging almost to black. This is probably one reason galenas are not on everyone's exhibit shelf, even though they are excellent examples of an isometric mineral. The mineral cleaves perfectly in three directions, which means that if you strike a piece of crystallized galena properly, you'll end up with a pile of tiny, bright, lustrous cube-shaped fragments that are brighter than the original simply because galena tends to dull on exposure to the air.

Interestingly, the galena from the Tri-State area contains virtually no silver in its composition. This is most unusual, as so many silver-galena deposits worldwide are rich in argentiferous galena, which is mined for its silver content. Some say the octahedral crystals of galena have this form because of a small amount of silver in the structure. It is more likely that the octahedral galena formed from a solution with a somewhat higher temperature. The silver mines of the world — in particular Mexico, which is the source of perhaps a fifth of all silver produced in the world — have mined so much galena as a byproduct that mines that produce just galena have a hard time making it financially. Galena from silver mines can be sold for pennies a pound as a major byproduct, and that has spelled the demise of many a lead mine.

Galena almost always occurs with other primary sulfides, especially sphalerite. These two sulfides are not complex and are easily formed, so are common in hydrothermal solutions that emanate from deep with the earth. For example, ocean-floor exploration has discovered hot hydrothermal springs gushing forth along the boundaries of oceanic crustal plates. These waters are so rich in mineralization that they are black, hence they are called "black smokers." As this mineral-rich hot water hits the colder ocean waters, minerals are immediately precipitated out and form layers on the ocean floor around the black smoker. Common among the minerals that form are our friends galena and sphalerite, along with chalcopyrite, which suggests how common they are in most hydrothermal emanations. It is entirely possible that these black smoker deposits may eventually cease to form and, through eons of time, be covered with ocean sediments, primarily limey deposits that become limestone and form blanket deposits not unlike those we see in mining today.

Sphalerite is an interesting mineral. As the most abundant zinc mineral, it has been found, just like galena, throughout the world. Unlike galena, which is easily smelted, sphalerite presented something of a problem to early metalsmiths. For one thing, it can look a lot like galena, which confused them. When they put the sphalerite into their kilns, it did not produce lead. The Greeks gave the mineral the name sphaleros, which means "treacherous," because it did not yield what the metalsmiths expected. Later, in Germany, where sphalerite was found abundantly with argentiferous galena, it was given the name blende, which means "to deceive," for the same reason.



JEFF KURTZEMAN PHOTO

Twinned calcites in many forms came from the Missouri lead mines. The model at right shows how perfect the natural crystal is.

Sphalerite can contain a considerable amount of iron in its structure. When it does, the black mineral is called "black-jack" by miners. In pure form, it is actually colorless, but only small, uncommon, colorless crystals are ever found, and never in the Tri-State area. More common are small, gemmy sphalerites ranging from yellow to red to green to brown. These gemmy crystals can be faceted, even though the mineral has a Mohs hardness of only 3.5 to 4. In spite of its softness, it is an attractive gem because of its absolutely brilliant fire or high refractive index. With an adamantine luster, sphalerite can be a very attractive mineral crystal.

Sphalerite is also popular among fluorescent mineral collectors, as it can respond beautifully to UV light, emitting colors ranging from orange to blue. However, none of the Missouri sphalerites are reported to be fluorescent.

Though sphalerite falls in the isometric or cubic system, like galena, it seldom forms cubes. The common crystal form for this zinc sulfide is tetrahedral, the form most often seen in Tri-State specimens. Sphalerite specimens range from black to red. The black crystals are often fairly large, exceeding an inch, and show facial growth patterns. They are sometimes found as spinel twins on a cherty matrix. Gemmy, bright-red crystals are much more common. They can be as small as a fraction of an inch, but exceed an inch in many cases.

What is interesting about the Tri-State sphalerites is that lovely, bright, brassy yellow chalcopyrites are often embedded in their faces. The brassy crystals show a nice tetrahedron form and are usually sharp-edged. What is remarkable about these copper sulfide crystals is their orientation on the sphalerite; they seem to line up in a definite geometric or linear pattern, evenly spaced from each other and uniform in size. Such orientation patterns are typical of minerals that develop epitaxial growth, in which their positioning is influenced by the host mineral's crystal form. Sometimes, black, somewhat rounded crystals are scattered among the chalcopyrite crystals on the faces of the sphalerite. They are very late forming sphalerites.

Both galena and sphalerite are minerals that, when weathered, produce interesting and sometimes rare secondary minerals. Surprisingly, the number of specimens of secondary lead minerals like cerussite and anglesite and secondary zinc minerals like smithsonite and hemimorphite are quite uncommon in the Tri-State area and you seldom see them on the market today. When found, they were usually insignificant as display specimens. This suggests a very shallow oxide zone, as opposed to what we see in the desert, where the oxide zone can reach as deep as 1,000 feet or more.

There are exceptions to this. My favorites are the hemimorphites that formed coating calcite. Later, the calcite was leached away, leaving wonderful hollow casts of hemimorphite in the form of the original calcite. Smithsonite casts after calcite have also been found here. Such rare specimens are quite highly prized.

The Tri-State marcasite was a late-forming iron sulfide mineral that most often formed as bright bronze to tin-white, spear-shaped crystals in radiating cockscomb groups on the other minerals. In some cases, they were found as stellate fivefing twins, but the cockscomb form is classic. While you may find Tri-State galena and sphalerite specimens today, you will see far fewer marcasite examples. One important reason for this is that this marcasite is unstable and affected by moisture. Many a fine Tri-State marcasite has simply disintegrated when washed or left exposed to very moist atmospheric conditions. A good marcasite that finds a home in Florida, for example, is not long for this world, the atmospheric moisture combines with the sulfur dioxide in the specimen to form weak sulfuric acid, which not only attacks the marcasite, but any other mineral specimen nearby!

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The most abundant and certainly one of the more attractive Tri-State display minerals is the calcite that formed separately and on the sulfide minerals. The calcite is mainly a late-forming mineral. The most quantity of the calcite formed as dog tooth crystals, curving, tapering pointed prisms, often with slightly rounded prism faces, so the normal hexagonal cross section shape is almost indistinguishable. Most Tri-State calcites are yellow to yellow-white. For the most part, the crystals are simple scalenohedrons, which tells us that they formed at fairly low temperatures. The crystals range in size from under an inch to 2 feet or more in length. They seldom show any modifications at all.

One exception to this rule is rhombohedral crystals of calcite that occurred uncommonly in some mines. Of these, a few showed an exceptionally beautiful pale violet color. These crystals were never common, so are seldom seen for sale. The finest examples I've seen are at the School of Mines Museum in Rolla, Missouri. Its exceptional display of Tri-State minerals, including superb calcites, is very appealing.

The Tri-State Mineral Museum in Joplin, Missouri, is another fine museum within the Tri-State area that has fine displays of the minerals from these mines. The museum is closed on Mondays and some holidays. Visit the Web site www.joplinmuseum.org, e-mail joplinmuseum@clandjop.com, or call (417) 623-1180 for specifics.

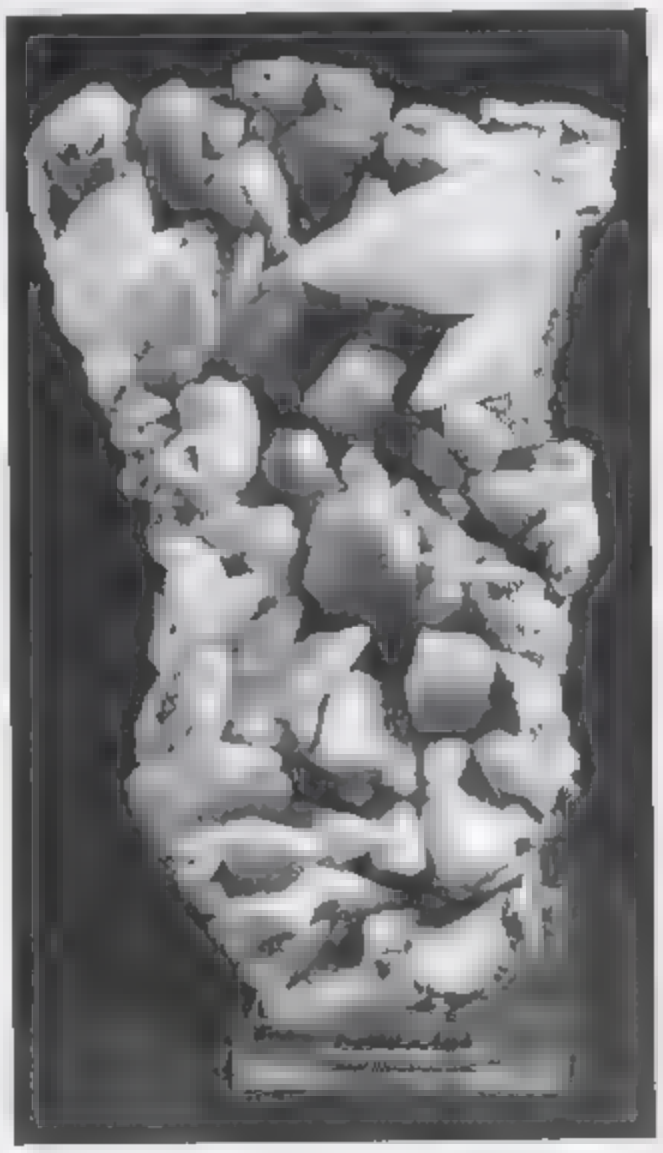
Though both the Southeastern and Southwestern Missouri lead mining areas have been virtually shut down, a new and much more recent discovery of lead deposits has become an industrial source of the heavy metal. After World War II, the modern mode of prospecting became airplanes flying over the land with a huge magnetometer sensor hanging beneath them. They were looking for deep deposits with no surface evidence of their presence, and were very successful.

In flights over the central part of Missouri in 1955, a deep-seated ore body was found. The region quickly became known as the Viburnum Trend. Located about 100 miles southwest of Saint Louis, this rich deposit runs more or less north to south from Reynolds through Bixby to Viburnum.

For the mineral collector, this was an exciting and fruitful discovery, mining here began producing some of the finest galena specimens ever found in Missouri or anywhere else. The galenas had brilliant luster, which is unusual for galena. Superb calcites, many of them phantoms, were also found in abundance. To add to the excitement for collectors, some of the world's finest pyrite "bars" were found. Bars are formed when square pyrite cubes stack repeatedly to create specimens that are square in cross section and usually an inch or so on an edge. The stacking results in long, barlike pyrites that can be upwards of 6 inches long. Slight displacement of successive cubes has caused some of these larger bars to curve gracefully.

The pyrite bars caused an immediate stir of excitement among collectors when they were found. The side faces of these bars always show cubic growth patterns and are often slightly to severely concave. The terminations of the bars are flat with slightly rounded edges. If broken, a pyrite bar reveals a most interesting growth pattern rather like an X or a cross running from corner to corner, which suggests these developed through rapid growth in one direction. Sometimes, a bar is curved slightly and may even show a slight twist. Other bars occur in groups of two, usually with one dominant bar and a second, smaller bar attached near the base.

The Viburnum Trend galena was nothing short of amazing. First of all, it occurred in simple cubes, often with cubelike growth patterns on the faces. Its mirror-bright luster, far more lustrous than galenas from any other source in Missouri, made it exceptional.



In this specimen, decomposed sphalerite-turned-smithsonite coated calcite crystals, which were then etched away.

The brilliance of the galena faces equals that of a freshly cleaved face. These lustrous faces do not dull quickly.

As for size, the cubes ranged from an inch or so to crystals so large they were impossible to lift. Some measured well over a foot on an edge and were a challenge to remove from underground via haulage shafts.

As attractive as the Viburnum galenas are, they are rivaled by the calcites from these mines. The common crystal form is scalenohedral with slightly curving faces. Some of these crystals show small modifications in the termination. They range from colorless to rich yellow. Some show included copper sulfides or iron oxide, which casts them with a fine reddish hue. Invariably, those calcites showing inclusions are always phantomed. Crystals would develop, then be dusted with microscopic crystals of a sulfide. Still later, a second overgrowth of calcite would enlarge the crystal and turn it into a calcite phantom. The coating mineral might be hematite, chalcopyrite, or even galena, so the phantom could be black, brassy looking or reddish. Some phantoms even show several such internal growths.

A second form of Viburnum calcite is the hexagonal rhombohedral crystals that terminate with sloping rhomb faces. These crystals tend to be slender, from under an inch to longer than 3 inches. They are most often bright yellow. The scalenohedral or dog-tooth crystals vary from under an inch to over 6 inches long. They often show "V" twinning, as well.

Much to the delight of collectors, a considerable quantity of all these minerals were brought out of the mines along the Viburnum Trend. Nothing is forthcoming these days, but when specimen production was high, plenty of superb specimens came to grass, so even today you see an occasional bright galena, sharp phantom calcite, or small pyrite bar for sale.

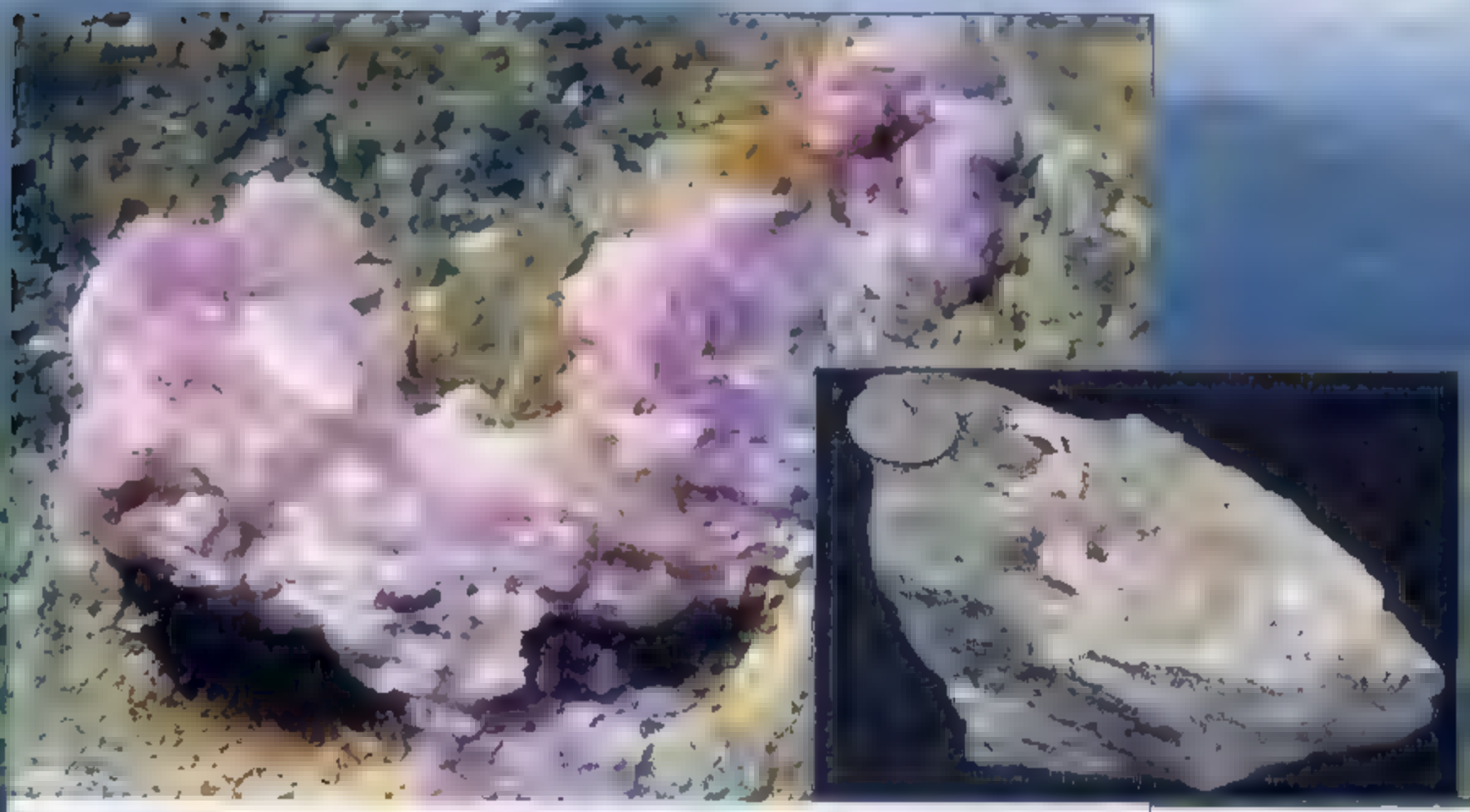
If you are interested in collecting sulfide minerals in particular, Missouri has certainly provided you with good examples to seek out at shows. With the vast amounts of galena, sphalerite, calcite and marcasite that came from the Tri-State area, now sweetened by the wonderful finds along the Viburnum Trend, every collection should have one or more examples of these minerals. The Viburnum species are much more costly, but that's because prices were higher to begin with and the supply was never as overwhelming as that from the Tri-State. So keep an eye out for Missouri lead and zinc minerals, and pick up a good calcite specimen, too.

FIELD TRIP

Chunky Gal Mountain Corundum Hunt

Colored Gems from Clay County, North Carolina

Story and Photos by Mike Streeter



Pink corundum can be found in pods and isolated grains in edenite amphibolite on Chunky Gal Mountain.

A fierce wind started to howl in the trees above us and the sky became almost black. Thunder began to crack directly above our heads as a very large thunderstorm descended upon us. All of a sudden, the sky opened up and a cold, heavy rain began to pour down. As we sat hunkered down beneath our rain gear, it felt like the temperature had dropped at least 15 degrees within minutes. The air was so thick with rain and fog that visibility could be measured in inches instead of feet. The small creek next to where we were sitting began to swell with brown water as runoff found its way downstream. The storm raged for nearly an hour before it moved off slowly to the east, leaving behind a blanket of fog that clung to the tops of the trees like a threadbare shroud.

Much earlier that same day, my good friends Wayne and Patty Brantley had come from their Tennessee home to spend a couple days in the Chunky Gal area of Clay County, North Carolina. This general area, referred to locally as the Gal, is perhaps best known by rockhounds for corundum in various colors. Since Wayne only hunts his precious #9 (on the Mohs Scale of Hardness), the Gal has been one of the Brantleys' favorite stomping grounds for many years. Wayne is the most knowledgeable and experienced corundum hunter around, and he and his wife are two of my favorite friends, so I was tickled pink when they asked me to join them on their two-day adventure. My wife Chrissy, and our dog, Opal, were eager to join us, but Chrissy's job would make her wait until Saturday to do so.

As I wrote in my book *A Rockhounding Guide to North Carolina's Blue Ridge Mountains* (www.McRocks.com), the aptly named Corundum Knob on Chunky Gal Mountain is a renowned corundum collecting location. Corundum deposits occur in dunite and associated rocks and have been worked since 1875. From 1878 until 1900, the mines in this area and in north Georgia were the world's only large-scale abrasive corundum producers. Although production from these deposits ceased by 1906, they helped to establish corundum as an American industry for the first two decades of the 20th century. According to "A preliminary report on corundum deposits in the Buck Creek peridotite, Clay County, North Carolina," by Jarvis B. Hadley (Strategic Minerals Investigation, U.S. Department of the Interior, Geological Survey, 1949), the corundum deposits were investigated by the U.S. Geological Survey to determine whether they would help to relieve the critical shortage of abrasive needed in war industries. They would not. The numerous cuts made by the Geological Survey can still be found around Corundum Knob. (Hadley's report can be obtained from the USGS at http://pubs.er.usgs.gov/pubs/b/b948E.)

The main dunite body making up most of Corundum Knob occupies nearly one-half square mile. Within the dunite are lenselike bodies of troctolite up to 70 feet wide by 1,500 feet long. Hadley's report states that troctolite is composed of olivine with varying amounts of calcic plagioclase feldspar containing secondary enstatite, amphibolite, chlorite-amphibole schist, or chlorite-olivine-serpentine rock. Gray corundum with hints of pink and blue can be found in pods or isolated grains in the troctolite. Small blood-red ruby crystals can be found widely disseminated in a beautiful pale green to emerald green rock called smaragdite, which is composed of mostly olivine, calcic plagioclase, and aluminous amphibole (edenite). Loose crystals of white, gray, pink, and blue corundum can be found by screening the gravelly soils in and around area creeks.

Corundum's specific gravity of 4.02 makes it feel heavier than all other area rocks and minerals.

The Chunky Gal Mountain corundum collecting area is in the Nantahala National Forest, and rockhounding is allowed. To reach the heart of the collecting area around Corundum Knob from Hayesville, North Carolina, drive approximately 17 miles on U.S. Highway 64 east to Glade Gap. At about 0.2 mile northeast of Glade Gap, turn left on a paved road that goes to Glade Branch. After about 50 yards, take the left fork onto a dirt and gravel Forest Service road. Drive about one mile to the parking area in front of a Forest Service bulletin board. Hike the trail to the east about 0.25 mile past Corundum Knob to the main smaragdite and corundum collecting area.

Old diggings and broken rock containing corundum may be found by hiking along the south, east and north flanks of Corundum Knob. There are numerous old prospect pits and cuts throughout the area in which to concentrate. These locations can best be found on maps contained in "A preliminary report on corundum deposits in the Buck Creek peridotite, Clay County, North Carolina."

Opal and I met Wayne and Patty at our agreed-upon location on Buck Creek Road Friday morning. Wayne was obviously giddy with excitement about finally getting a chance to hit the woods again. We geared up and headed off into the woods toward one of Wayne and Patty's "private" spots along a small creek. Before long, Wayne had his eyes on the ground and hands in the creek's cold water, scratching for signs of corundum with his custom-made titanium mattock. He pointed out a few likely spots to dig along the relatively untouched creek, and I started doing a little scratching of my own, albeit with a larger mattock and shovel. Wayne prefers to hunt by feel, without the use of a screen, whenever possible. This way, he sorts the rocks with his hands and picks out the ones that seem heavy or that show the cleavage faces or form characteristic of corundum. This concept works for me because I'm generally concentrating on finding the "big one" anyway. Before the morning was over, we all would find more than a few chunks and crystals.

We took a break around noon to eat our lunches. Not long after we had gotten back to scratching in the creek, we were threatened by the aforementioned thunderstorm. Expecting it to rain anytime, Patty and I donned our ponchos, while good old Wayne continued to scratch in the creek. Before long, though, even Wayne was forced to give up his digging, as the creek had swelled to near its banks. Opal is a little bit afraid of thunder, so I let her get up under my poncho and we all sat to wait out the storm. After about 45 minutes, the storm finally passed and we were able to get back to the hunt.

By late afternoon, we were satisfied with our take and the wet and cold finally got to us, so we decided to call it a day. We made arrangements to meet the next morning to hit another area on the Gal. I drove back home to Candler, while Patty and Wayne drove to a motel in nearby Franklin.

Corundum is very resistant to weathering and often stands out from the less resistant edenite amphibolite country rock.

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Chunky Gal *from page 89*

Corundum belongs to the hexagonal crystal class, so it often forms as six-sided crystals

Chrissy, Opal and I drove out to the Gal Saturday morning to meet Wayne and Patty, who were already there waiting. It was a cold morning, and the weather forecast was not calling for much improvement that day. We warmed up pretty quickly, though, by hiking the steep, thickly forested slope where Wayne had planned to show us some of his favorite spots. There was no trail, we all just followed Wayne's nose. Along the way he pointed out certain landmarks, like the tree that had blown over in 1993 or the pile of rocks that somebody had stacked back in 1982. Wayne knew where all the different types of rocks were located, including the best places to find corundum. Along the way, we paid a visit to "Patty's Rock," a 250 plus pound boulder that was dotted with pink corundum blebs. Getting that rock down the mountain is a job for a much larger person than me. The boulder is still there if you want to try your hand at lifting it and carrying it out. Start at the dirt road just above the creek, hike up the slope, and go past the 2,132nd tree to the end of a large cut. The boulder is on the west side of a big oak. Good luck!

The first spot we stopped at was an old cut that Wayne, the walking, talking history book, told us was dug in the 1940s. Near the cut was a large hole that had been dug by prospectors and enlarged later by Wayne. Scattered around the cut and hole were large boulders of mostly edenite amphibolite. Patty found a large rock that was covered on one side by what appeared to be pink corundum. The rock was heavily stained with iron oxide and covered with dirt, but the highly resistant corundum made the surface of the rock appear bumpy. With her sharp and experienced eye, Patty was able discern that the bumps were corundum, as a bit of pink showed through. She gave the rock to me to cob down to a more manageable size. The rock broke just right and somehow ended up in my pack. I have since cleaned the specimen by washing it, scraping away the weathered and oxidized material, and cooking it in oxalic acid. It turned out great!

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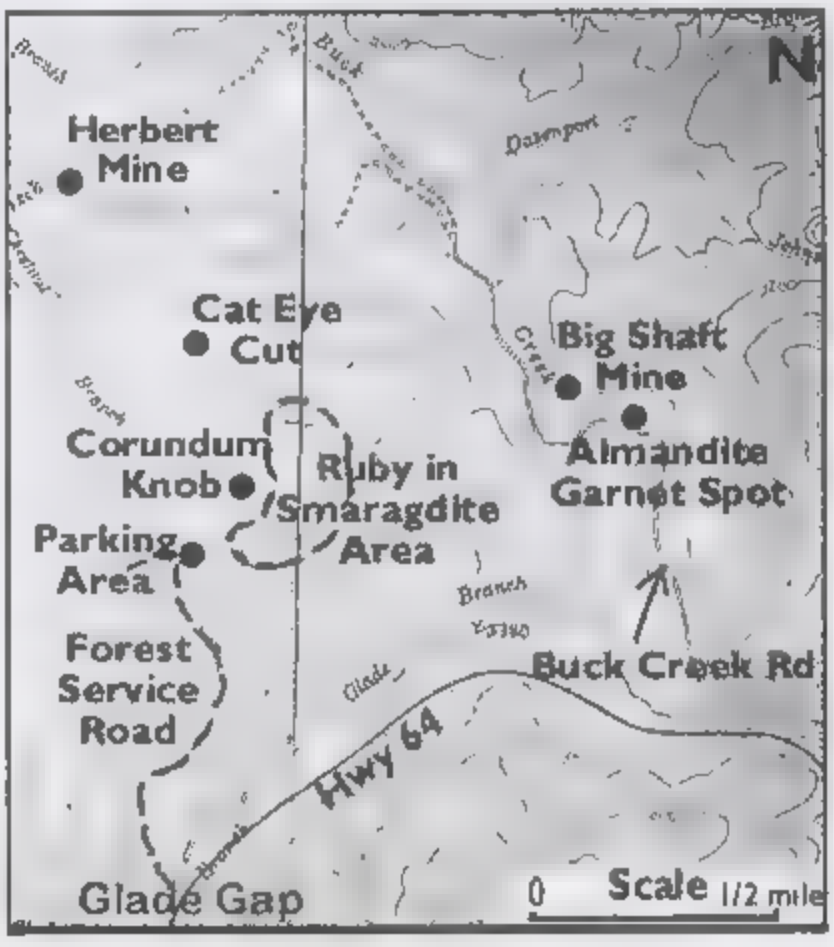
Even the smallest mountain stream can expose rocks, making it easier to sort material and find corundum.

Chunky Gal *from page 90*



We surface collected and dug up a whole bunch of boulders that I attacked with my 6-pound sawed-off sledge. Not to be outdone, Chrissy went after some of the smaller rocks with her 3-pound crack hammer and chisel. The eclogite amphibolite in this particular area of the Gal is incredibly hard and unweathered and contains a fair amount of white corundum, so breaking it is very difficult. Wayne and Patty knew to turn their heads in the opposite direction any time I started swinging the sledge, as the rock chips were flying in all directions. We managed to find several more specimens dotted with pink and white corundum.

By late morning, we decided to move on to another location farther up the mountain. We bushwhacked upward through the thick forest and rhododendron thickets to an area on a creek just below a cat dug by the USGS in the 1940s. Since the USGS was performing mostly exploratory work and this area was never commercially mined, plenty of corundum was left behind for rockhounds who are willing and able to dig for it. Those who frequent the Gal will tell you that it is necessary to screen all the dirt you dig in a creek, but Wayne employed his dry digging technique, whereby one feels through the soil with his bare hands for corundum and finds it, mostly by its weight and shape.

I've never been much for screening, so I picked a likely spot in the trench spoil pile. I dug a hole down to weathered bedrock, pulled down material from the sides of the excavation, and looked and felt for corundum as I went. I suppose that one might find a fair amount of small corundum pieces in the dirt that I threw out of the hole because, as usual, I was hoping to find the bigger stuff.

By midafternoon, the temperature had dropped and a bit of sleet began to fall. Wayne and I stayed busy digging, if for no other reason than to stay warm, while Chrissy and Patty combed the area surface collecting and catching up on small talk. As the afternoon progressed, we were rewarded with some decent pink, yellow and white corundum chunks and crystals.

At around 4 p.m., we decided to check out another cut or two. Wayne wanted to visit a few more of his many holes and cuts to see what changes had taken place since the last time he and Patty were there. He pointed out this hole and that hole, telling us when he dug them and how much each had been enlarged by subsequent rockhounds. Throughout the two days spent on the Gal, I noticed that many of Wayne's old digging spots did not appear to have been touched. I guess that is his reward for a vast knowledge of the area, which allows him to stay off the beaten path. If you are on a well-worn trail and you find a hole, it probably wasn't dug by Wayne, or else he dug there before the rest of the thundering herd stumbled upon it.

It wasn't until late afternoon, when we were on our way back down the mountain to our vehicles, that the sun finally decided to make a brief appearance. We sure could have used it earlier in the day to keep us warm and to better spot the corundum. But our time spent on the Gal wasn't just about how much corundum we found, and we found plenty; it was about getting back to nature and spending time with good friends.

After we got back to our vehicles, it didn't seem like Patty and Wayne were quite ready to leave, so we took a leisurely stroll along a Forest Service road. I guess it was their way of bidding farewell to the Gal. Sometimes, you can find an errant corundum crystal even in the middle of an area road, but none of us were really looking very hard by then. We hiked about a half-mile up the road before heading back to where we had parked. After saying our good-byes to the Brantleys, we took a cue from a soon-to-set sun and called it a day.

LAPIDARY LORE AND MORE

Mineral Hunting in Maine

by June Culp Zeitner

The Zeitner trailer, "Tipi-Omani," and specially made straight-eight Crysler New Yorker, "Lochinvar," took Albert and me on our mineral hunt across Maine.

After traveling through Canada, Albert and I entered the United States at Jackman, Maine. We headed for Augusta, which we had chosen as our headquarters for searching the mineral and gem fields. In 1950, trailers (now called RVs) were rare, and RV parks rarer yet. We stopped at the largest gas station in town for a fill-up and asked where a good trailer park was located. We were told there were none. Albert asked if there was one near Paris, New Paris, South Paris, or West Paris. The station manager responded, "You sound like rockhounds. The geologist across the street is gone a lot, but he left a special message for rockhounds."

He handed Albert a note that read, "You are welcome to park in my yard. There is an electric and water hookup on the left side of the house under the maple tree. Stay as long as you like. No charge. Good luck on your hunts." It was signed "Wayne Stewart."

Of course, we took advantage of this warm welcome. Our trailer remained there for over a week while we scoured the mountains for tourmaline.

We had read about Stanley Perham and his Maine Mineral Store at Trap Corner. We were eager to meet him and to visit the historic Mount Mica. Perham was generous with his time and knowledge, and showed us fine examples of the wonderful rainbow colors of gem tourmaline.

Armed with a detailed map, courtesy of Stan, we arrived at Mount Mica early the next morning to dig for tourmaline. I soon found some lavender lepidolite and some light pink quartz.

Albert was close to the top of Mount Mica when he found our best specimen. It has many pink crystals on white quartz. The quartz becomes water clear around the best crystals, most of which are chipped or fractured. It is certainly not a museum-quality specimen, but it is attractive and we had the fun of discovering it.

Mount Mica is noted for beautiful pink and blue-green tourmaline crystals. Much of the pink had a hint of lavender. The most interesting crystals here were called "watermelon," a descriptive name for these unique crystals that feature deep-pink centers encased in rich green borders.

Rose quartz crystals were virtually unknown years ago. A mine in Maine produced a small amount. While in Maine, I had the opportunity to buy a specimen. I don't know why I bought one. The crystals are small and crude and lack luster and perfection.

Naturally, Mount Apatite was on our agenda and on the map Stan had given us. The apatite crystals were a lustrous blue-violet, but I didn't buy one, and of course, I have been sorry ever since. Each year, the one I turned down grows bigger and more spectacular in my mind.

Sodalite is another of Maine's treasures. The blue of sodalite, while not as intense in color as lapis lazuli, is one of its components. Closely related are hauyne and lazurite. Sodalite has been found in meteorites, which is quite appropriate since it is sometimes sky blue.

Maine has its quota and more of beryl. Large, flawless aquamarine crystals come from Stoneham, as does the rare beryllonite. The aquamarine colors vary green, yellow-green, and blue-green, with tints and shades of each. Then there is colorless beryl (goshenite) and one pink beryl (morganite). Golden beryl (heliodor) is a splendid member of the beryl family. The rich green color of emerald is due to chromic acid, which is lacking in the green beryls of Maine. Various green beryls occur in several Maine townships.

We did not leave Maine until we had tried our luck at hunting Maine's freshwater pearls. One location was at the tributaries of Moosehead Lake. I did find one peculiarly shaped white pearl, not very impressive—after opening enough mollusks to make clam chowder for a seafood restaurant.

It was interesting traveling through Maine and seeing the evidence of their severe winters. The farms had the house connected to the barn, connected to the chicken coop, connected to the machinery garage. (That reminds me of an old song.)

As we left Maine, the maple trees were scarlet, Macintosh apples were being sold at roadside stands, the geese were headed south, and a silver coat of ice covered the ponds. ❦

Montana's Bountiful Treasures

Part II: Gem Mining in the Sapphire Mountains

Story and Photos by Kenneth H. Rohn

In the last installment, I visited the historic gold rush towns of Virginia City and Nevada City, where I spent two days reliving history and walking the streets of these old mining communities that rest between majestic mountain ranges. While in the area, I visited Steven Cox's Red Rock Mine and Gallery, and had a hands-on experience recovering gem-grade almandine garnets. I also met Hart Battis, CEO of Ruby Garnet, and was given a personal tour of Commco American's mine and commercial garnet operation in Alder, Montana. Then, I was off to the city of Butte where I met Sarah Bannon, Gold West Country Executive Director.

After having lunch and an exciting trolley ride through the city of Butte with Sarah, I was on my way to Boulder, approximately 40 miles north of Butte, just off Interstate 15, where I met Donnie Sexton, Staff Photographer/Publicity Manager for Travel Montana. We took a tour of the Free Enterprise Radon Health Mine in Boulder.

The mine opened in 1924, when silver and lead ore were thought to be rich enough to make a profit on the property. After only a short period of mining, during which a few shipments of ore went out, the underground mine was shut down and abandoned. Then in 1949, when uranium was on the lips of every prospector in the country, three men, one of them mining engineer/geologist Wade Lewis, discovered radioactivity with their Geiger counters on the mine's waste dump.

I collected these magnificent sapphire crystals, one of which is a beautiful purple, at the claim deep in the Sapphire Mountains.

The reason for this great interest and excitement was the creation of the first self-maintaining nuclear chain reaction on Dec. 2, 1942, during World War II, which ushered in the atomic age. Pitchblende, a dark brown to black, shiny mineral containing radium/uranium, a most important ingredient in atomic fusion, was in big demand during this time, and for several years after the war. As a matter of fact, the government offered a reward of several thousand dollars to the lucky discoverer of a deposit of uranium ore. I would assume that a few prospectors did collect that prize.

The old silver mine property was leased in 1949 and named the Free Enterprise Uranium Mine by Lewis and his associates. A shaft soon extended down to 150 feet, and mining began. During the process of mining this rare mineral, observers were allowed to visit the mine. While underground, some spectators began to notice that they were relieved of pain after a few visits. It was soon ascertained that radon gas was present in the mine. Word spread about this strange odorless, tasteless, colorless gas, which

One sapphire can be heavily worn, while another recovered from the same screen load is a perfectly formed hexagonal crystal.

If properly shaken, the heavy sapphires will lie on top of the lighter material when the screen is turned over.

seemed to be so beneficial. It wasn't long before countless suffers gathered at the mine entrance, demanding to be let in and completely disrupting the mining operation.

After much contemplation, the uranium operation was abandoned and it was decided that the mine would be used as a health site, and has been ever since. Originally operated by Lewis for a good number of years, the mine is now run by his granddaughter Patricia Lewis and her husband, B.E. Anderson.

After Donnie and I registered and had a most interesting and educational talk with Patricia, we rode down to the first level in the elevator and stepped out into a well-lit tunnel carved out of solid rock. Along the long tunnel (drift), rooms were cut in the side walls for people to sit in and read or play games while they spend time in the mine, absorbing this strange radon gas. It was not damp, as I had anticipated it might be, but just the contrary. I was also quite comfortable in my shirt sleeves.

I asked one lady how she felt, and she told me that she was doing well, having spent several sessions in the mine previous to our visit. Other folks were playing cards in one room, and they greeted us as we took photos and made our way toward the end of the drift. We asked about the lower level and were told that it no longer is available to the public.

Of course, Donnie and I were there strictly to observe. After our visit and photo session, we returned to the surface, had a long talk with Patricia, and went on our way. I was impressed with the amount of work that had been done on the premises while it was still classified as a uranium mine, and later as a health mine.

Radon (Rn) gas (atomic weight 222, atomic number 86) is a radioactive chemical element combined with alpha rays as a first product in the atomic disintegration of the element radium. Since its discovery, it has been somewhat of a controversy and an enigma. It's up the individual to form her or his own opinion of the subject.

After leaving Boulder, we drove to Helena, with Donnie leading in her vehicle. We stopped at a supper club, where we had a chance to renew acquaintances and enjoy a delicious meal. Then, as the sun was getting low in the western sky, I made my way northwest to Clinton, Montana, and my next adventure via U.S. Highway 12 and Interstate 90.

FOUR DAYS IN THE SAPPHIRE MOUNTAINS

I spent the night at the L-Diamond-E Guest Ranch Outfitters in Clinton, in a new, luxurious cabin. I met Dan and Retta Ekstrom in their beautiful, rustic lodge and talked about the adventure that awaited me. I would soon be mining sapphires at a private claim. The number of gemstones that I acquired would depend upon the amount of time I invested in recovering them.

The Ekstroms have a registered and proven sapphire claim, nestled in a magnificent valley of the Sapphire Mountains, with a clear, cold stream flowing next to camp. To get to their claim at an elevation of close to 7,000 feet, our group, which included Dean and Renee Dutton, Gary Salvador, Tom Moresson, Dan's assistant and hostler, and me, took an 11-mile mountain trail to camp. Along the way, I saw some of the most picturesque scenery that one can imagine anywhere.

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People sit and read or play games while they spend time in the Free Enterprise Radon Health Mine, absorbing radon gas

Early next morning, I rode with Tom, Dean and Renee to the trail head in a truck pulling a trailer load of horses. Dan and Gary rode in the other truck with more animals in back. After saddling up, Dan pointed out my horse, a big yellow beauty named Buckey. I asked Dan if he had backed anyone off recently, and he responded with a chuckle, "He's been pretty good lately. He hasn't bucked anybody off for two or three days." Buckey turned out to be rather gentle and carried my 200 pounds with no difficulty.

Dan led our party of six, along with six pack mules, into the vastness of the Sapphires. Three extra mules were taken along because this was to be the last trip of the season. They'd help carry the tents and equipment out. Everything that would sustain us for four days was carried by the mules. Contrary to popular belief about the stubbornness of these animals, Dan's were very cooperative. When planning the trip, I was asked to pack my gear in a soft duffel bag and to try to keep the weight at 50 pounds so as to spare the mules. Mine was about 35, including my camera and equipment, and I really didn't need all the clothes I took along.

Although I have ridden various types and brands of motorcycles for much of my adult life, it had been a good long time since I had ridden a horse. The difference is astounding. Of course, the rider has to be in tune with the animal, keep the saddle upright at all times, and more or less obtain a good equilibrium, with feet properly placed in the stirrups. Dan's horses are neck trained; that is, if you want to go left, you simply let the rein touch the right side of the horse's neck, and vice-versa.

At the half-way point, we took a break, gave the horses a rest and had lunch on the trail. We still had another hour and a half ride into camp. The view from this lofty rest area is spectacular!

It was early afternoon when we arrived at camp. Quite a while before reaching our destination, I noticed the horses were walking at a faster gait. They knew they could soon rest.

We found the sapphire camp to be very quiet and serene. The only foreign sounds we heard while there, besides the gurgling stream and birds singing, were those of an occasional high-flying jet. The weather was ideal, with warm days and cool nights and a bright, clear, deep blue sky every day. It's no wonder Montana is called Big Sky Country.

Everything was set up and waiting for us. We each had our choice of a spacious tent. A cold mountain spring provided crystal-clear, pure, cold drinking water (an unusual situation in this day and age) a hundred yards above camp. It's strange how often a spring will be located at a high point in a hill or mountainside.

I was tired and a bit sore, I felt it mostly in my knees and thighs, but it soon went away during activity around camp. After the pack mules were unloaded, we stored our gear in the tents. We were told to pick a pair of rubber boots that fit us from the supply in the main tent, because we would be working in ankle-deep water much of the time. (If you choose, you can pack in your own boots and rubber gloves.)

Dan led us down the trail to the sapphire claim next to the creek. We found all the necessary tools, along with several pairs of rubber gloves, neatly stacked and ready to use. Dan took a bucket and bailed water out of a hole next to a high gravel embankment that had produced a substantial amount of crystals on the previous trip. Seepage made it necessary

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Rock Science

Steve Voynick

Calcite, Limestone...and Cement

Calcite, or calcium carbonate ($CaCO_3$), is among the most widely collected of all minerals. Abundant and generally inexpensive, calcite crystals occur in a variety of interesting habits and are often strikingly beautiful.

Although calcite is our most common carbonate mineral, most of it is locked up as microcrystals in limestone, a marine sedimentary rock consisting of at least 50 percent calcium carbonate. Because it is frequently fossiliferous, limestone is often a collectible rock. And because it is the raw material for manufacturing lime and cement, limestone is by far the most widely mined of all sedimentary rocks.

Lime (also known as quicklime, burnt lime, or caustic lime), is calcium oxide (CaO). It is produced by calcining (heating nearly to fusion to remove volatile substances) ground limestone to drive off carbon dioxide from calcium carbonate in the simple reaction $CaCO_3 \rightarrow CO_2 + CaO$. Lime is used to manufacture glass, paper, masonry mortar, and whitewash, as a water-softening and soil conditioning agent, and in leather tanning and sugar refining.

The bulk of all quarried limestone, however, becomes the key raw material for the manufacture of portland cement, the world's most widely used, inexpensive, and durable construction material.

Portland cement is primarily a mixture of tricalcium silicate ($3CaO \cdot SiO_2$), tricalcium aluminate ($3CaO \cdot Al_2O_3$), and dicalcium silicate ($2CaO \cdot SiO_2$). It is made from limestone and a source of silica and alumina such as clay, shale, or blast-furnace slag. These raw materials are ground together with limestone and fed into a long, continuous rotary kiln. First, heat calcines the calcium carbonate into calcium oxide. Then, at temperatures of about 2,800 degrees F, the entire mixture fuses and reacts chemically. The end product is "clinker," a gray-brown, chunky mixture of calcium aluminates and calcium silicates, which when ground into a fine powder becomes ready-to-mix cement.

When mixed with water, cement's components break down into caustic calcium hydroxide and a gellike mix of hydrated calcium silicates and aluminates. With a slight loss of water, these compounds recrystallize into nonhydrated silicates and aluminates, "setting up" as an interlocking mass of tiny crystals. In use, cement is mixed with an aggregate material (sand or gravel) and sets up to form a solid, hard, very durable concrete.

While the cement-manufacturing process is simple enough, it actually took thousands of years to develop. Egyptians used the first lime-based cements, mixtures of calcined limestone and quartz sand, to construct many of their pyramids. The Greeks built their temples with similar cements.

But lime-quartz cements do not produce truly durable concretes. Quartz, or silicon dioxide, which is largely inert, has a dense, compact crystalline structure into which calcium hydroxide molecules cannot penetrate and react, thus restricting bonding only to the surface of the sand particles. This limits the overall strength of the concrete and prevents it from setting and hardening underwater.

The Romans developed the first modern, lime-based cement by substituting a volcanic ash from Mount Vesuvius for the traditional sand. Unlike quartz sand, the volcanic ash, rich in various silicates and alumina (aluminum oxide) and already naturally calcined by volcanic heat, has a porous structure. Upon addition of water to the Roman cement, the powdery, porous volcanic-ash particles provided a huge surface area to maximize the reaction with the calcium hydroxide. The result was a concrete as strong as the best modern concretes, as demonstrated by the many examples of Roman architecture, including the Coliseum and Pantheon, that still stand today.

The formula for Roman cement was lost for 1,400 years, but was finally recreated in England in the early 1800s. The English cement, which employed clay rather than volcanic ash, became known as portland cement because its concrete matched the color, hardness, and durability of the gray Jurassic limestone of England's Portland Peninsula.

Today, a whopping 1.5 billion tons of portland cement are manufactured worldwide each year. And that's something to consider the next time you look at your prized calcite crystals and fossiliferous limestone specimens, or even the concrete sidewalk in front of your house. ❖

Dan Ekstrom digs sapphire-bearing gravel from the mine's prospect hole for screening.

to siphon off water with hoses from time to time while we were there. When it was shallow enough, he shoveled some of the gravel onto a plywood board at the edge of the hole, and we were soon washing and screening buckets of gravel in the creek.

Dan left to prepare our evening meal in the cook tent. He's an excellent chef, and we ate as though we were at a five-star restaurant. We did some preliminary work at the claim, but it was getting late and supper awaited us in camp. No sapphires came to light during that first afternoon.

My sleeping bag felt very comfortable that night and I dozed off thinking about past events and what I might discover in the morning. The last thing I remember is hearing the hooting of an owl in the distance.

I awoke at daybreak, having gone to bed much earlier than I would at home. It was rather cool when I stepped out of the tent, so I put on my jacket. The air was crisp and fresh and the water in the stream was near the freezing point—or so it seemed when I splashed water on my face and hands. Even though it was August, the altitude has a great influence on the weather.

The others were getting up and gathering around the cook tent when I got back. Dan had a fire going in his stove and the aroma of coffee filled the air. I could hardly contain myself thinking about the prospect of recovering those beautiful sapphires that were waiting for us in the gravel bank.

After an excellent breakfast of pancakes, bacon and eggs, we set out down the trail to the diggings. It's probably two long city blocks from camp, and the trail follows the stream. Old Sol was just beginning to rise over the distant peak when we arrived at the mine at 9:30 a.m. I put on my boots and a pair of rubber gloves and went to work. It was to be a most interesting and exciting day.

Gem-grade corundum—that is, both sapphires and rubies—is composed of oxide of aluminum (Al_2O_3). Pure corundum is colorless, but slight traces of other elements, such as titanium, iron and chromium, give many stones their magnificent coloration. It has a hardness of Mohs 9, second only to diamond.

The specific gravity of sapphire can be anywhere from just under 4 to as high as 4.10 in some cases. This weight works in our favor while recovering them, as they are much heavier than the surrounding gravel. Sapphire crystallizes in the hexagonal system and, as is the case with the Ekstrom sapphires, many tend to be beautifully elongated hexagonal barrel shapes, if they aren't water worn. Strangely, one sapphire can be heavily worn, while another recovered from the same screen load is a perfectly formed hexagonal crystal.

Many compact gem-grade stones don't show any sign of cleavage. This can cause the lapidary difficulty in cutting and faceting. This type often has a bad habit of breaking into worthless fragments if handled improperly.

Sapphires were first discovered in the Missouri River gravels northeast of Helena in 1865. As is the situation with the Ekstrom claim, the sapphires are not in deposits; that is, they seem to have moved around through the eons,

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On The Rocks

Adventures in Emerald Mining

I've had plenty of excitement while researching mineral stories, and even had the odd scare or two on my journeys. The scariest trip I ever made was into the emerald mines of Colombia. That South American country is not high on the tourist safety list, and when you venture into the remote reaches of the deeply ravined jungle and get involved with the digging of highly valuable gem crystals, it can get pretty dicey. Hitting just one pocket of emeralds can make a poor man a millionaire overnight! No wonder there have been so many robberies, killings, and attempts at fraud in this almost lawless region. Going there can be really exciting—and just a little scary.

I was approached at the Denver Show by a dealer who asked if I was interested in going to Colombia, visiting the emerald mines, and writing about the trip. Never one to turn down an adventure, I was soon flying from Phoenix to Houston to Bogotá with Don Bochner, dealer in fine emeralds. Don and his partner, José Vesga, were looking for some exposure for their emerald business. José lives in Bogotá and Don is a commercial pilot who got into the gem business almost by accident.

When we landed in Bogotá, we were met by José, who had made the arrangements to go to the mines. We didn't waste any time in Bogotá. After deplaning, we simply walked out across the airport asphalt taxi ramp area and boarded a small two-engine plane. There are only two ways to go to get to the emerald mines. You can make the arduous drive through miles and miles of jungle, which is strongly discouraged for gem buyers because of the risk of highway robbery, death and kidnapping! The other option, quite safe if the plane functions as expected, is to board a puddle jumper and fly into Quipama, a small village about 15 miles from Muzo, our destination.

The two-hour flight was very safe and interesting. The Quipama field was a single strip carved out of the jungle. Radio communication between ground and plane was by walkie-talkie, hardly the most up-to-date electronic equipment. The ground crew, a young girl, was able to tell the pilot when the strip was clear of pigs, which wander across it looking for food.

As we drove through Quipama to Muzo, I noticed a fairly long line waiting to get into the store. José explained that the store had the only radio telephone linking the area to Bogotá. I fully expected to see someone hand-cranking a power generator, but was assured they had electricity.

Though I live in the Southwest desert, I had never experienced such local roads. Our driver was the owner of the hotel where we would be staying in Muzo. He must have taken us the scenic route, because it took three hours to go those 15 miles. Actually, using the term "road" is a bit of a stretch. Our vehicle was a fairly new Toyota Land Cruiser with about 12,000 miles on it. The roads are so bad that this vehicle had already had one universal joint replaced on the drive shaft, and before we were done, it was given another one. The only nice thing was that the cost of replacing a universal joint was $12 US.

The hotel in Muzo was adequate, nothing more. For example, there was no toilet seat on the only commode. The only shower, also a community affair, was a single rusty water pipe sticking out of the wall. Next to it was a 50-gallon barrel full of water with a gourd floating in it as a scoop. The idea was to douse yourself with water from the barrel, soap up well, if you brought soap, then turn on the faucet and rinse off. Talk about shock! The shower water was absolutely frigid mountain spring water.

The mines at Muzo, Colombia, produce choice emeralds that are highly prized.

The next day, we headed for the mines, huge, open-cast mountainsides that had been torn apart for centuries. The slopes consist of pitch-black shaley rock cut by an occasional white streak of calcite. Mining is done by benching the mountain slope; bulldozers carve away layer after layer of the black, filthy, shaley rock hoping to expose a gem crystal pocket in the white calcite. Since the emeralds occur largely in the calcite, the black rubble was simply pushed downslope into the river below. There, a horde of garimpieros, exceedingly poor folks, scavenge the rubble for a glint of green.

When a white streak of calcite is exposed by the machinery, all work stops and hand digging begins, always closely overseen by the mine owner, his son, or another close, trusted relative. If any indications of a pocket show up, usually small brown parisite crystals in the calcite, everyone steps back and the company guy moves in to open the pocket. The larger stones are collected, put in a locked pouch, and taken by jeep to the main office to await a helicopter flight to Bogotá. The emeralds never hit the ground again; the helicopter lands on the roof of the emerald exchange in downtown Bogotá. This building houses all the emerald dealers, treatment and sorting rooms, administrative offices, and huge safes!

The company man never collects all the emeralds from any pocket discovered. He always leaves a few of the smaller crystals for the miners to collect and sell. This is how the miners get paid.

This amazing area has been producing "green fire" for perhaps several thousand years. When the Spaniards arrived, they were greeted by local native chieftains wearing garments encrusted with lovely green hexagonal crystals. Emeralds were part of the gifts, and later tribute, given to the Spaniards. All that did was arouse base greed in the foreigners. The Spaniards wanted to know where these magnificent green bolts were being mined and tried to extract the information from the locals by any means. In spite of torture and death, the Spaniards were never able to actually pinpoint the mines. The locals had stopped mining and the jungle had totally obscured the mines.

The biggest problem the Spaniards had was the local natives, the Muzo Indians. These fierce natives not only refused to reveal the source of the emeralds, but whenever the Spaniards invaded their territory, the locals defeated the Spaniards time and time again.

by Bob Jones

In desperation, the Spaniards brought in fierce hunting dogs. That did the trick. The Muzos, who had never even seen such dogs, were defeated. But still, no one would reveal the source of the precious emeralds. Then one day, a Spanish officer was riding his horse along a riverbank when his horse came up lame. Stopping to check the cause, the officer found a small emerald crystal jammed in the horse's hoof! The emerald deposit was revealed.

Since that time, millions of carats of emeralds, the finest in the world, have come forth, and it was my goal to go underground and see these green beauties in place. While open-cast mining is common here, most of the mines today are underground, dug to follow the white calcite veins wherever they go.

The first mine we visited was underground, so to get to the working face, I had to walk into an adit to a vertical shaft where I had to climb some 100 meters down a slippery metal pipe ladder. When I finally reached bottom, I stepped knee-deep into the filthiest black sludge I'd ever seen. I stepped aside to allow my escort to get off the ladder, a big burly guy carrying a submachine gun! He followed me wherever I went. I was never sure whether he was guarding me or making sure I didn't pocket something green.

At the bottom of the shaft, I saw no sign of emeralds or calcite. Those walls of carbonaceous shale turned everything black, while absorbing most of the light coming from my lantern and the dim bulbs hanging from wires tacked to the tunnel roof.

To get to the working face, we walked about 1,500 meters. Have you ever walked that far in a half crouch? I found muscles I never knew existed in my legs!

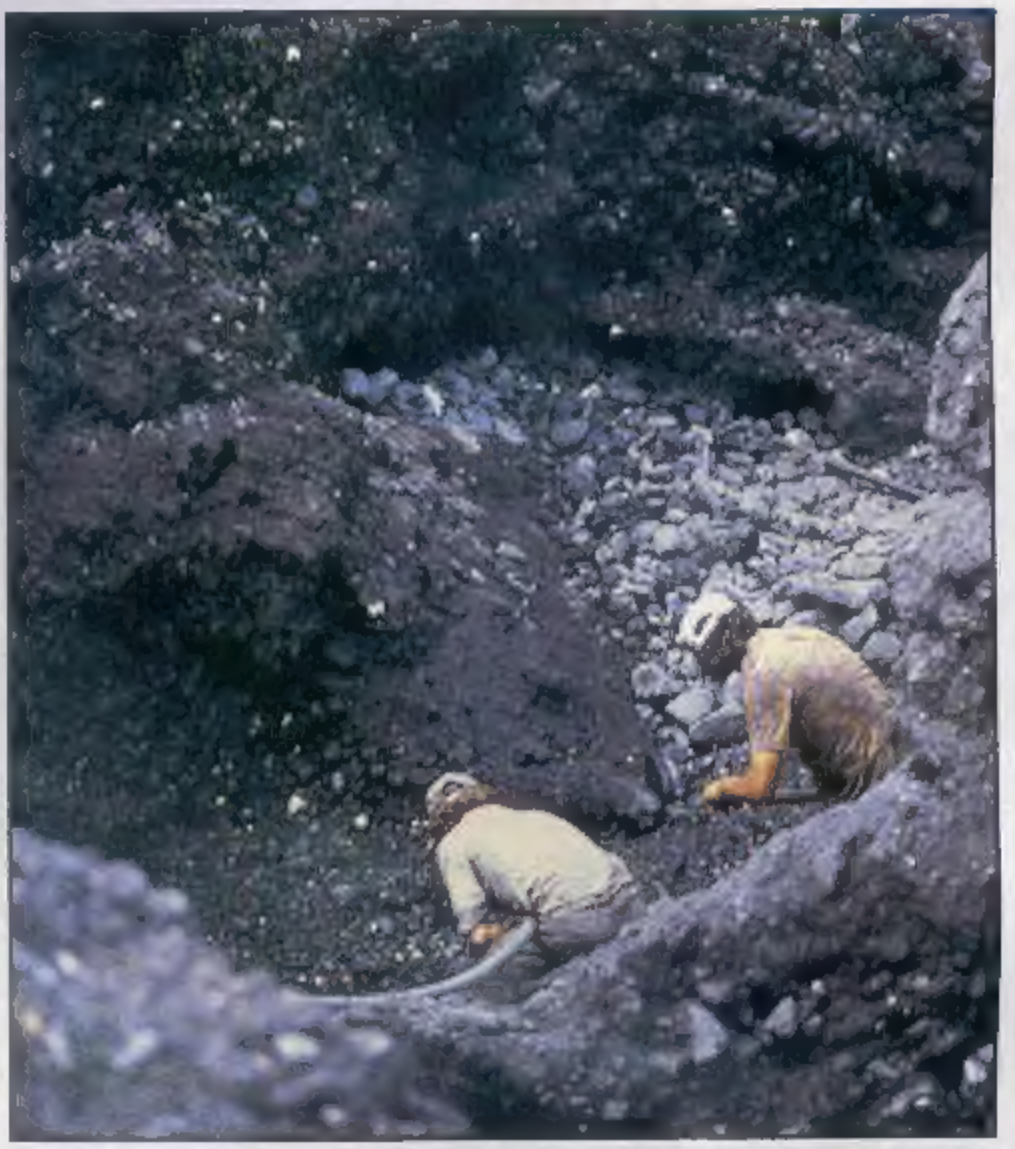
Finally, we came upon three miners working a 2-foot-wide calcite vein. One was drilling, one was assisting, and one was supervising, making sure no emeralds fell into someone else's hands. Security is paramount in the emerald mines. A single crystal can bring tens of thousands of dollars in Bogotá. I could not see any emeralds in the calcite, but it was still worth seeing mining being done here.

Later, my escort, the mine superintendent, took us into another tunnel. To get into that tunnel, he had to unlock a huge steel door. Behind it, a lone miner was digging a calcite vein that had green crystals jutting from it. They sparkled even in the dim light. What a sight! After I had a good look—I wasn't allowed to touch—the superintendent took a rock pick, dug out a handful of crystals, and pocketed them.

This was just one of six mines I was able to enter. At every mine, I saw more guns than rock picks. And there was always my faithful armed escort carrying that evil-looking automatic rifle.

One of the most interesting events at the emerald mines is buyer's day. Instead of paying miners a wage, many of the mines will allow their miners to have the smaller crystals left after management cleans out a pocket of the really juicy hexagons. In earlier days, the miners had to take time off from work and go to Bogotá to sell their crystals, or sell them locally for a lot less. Miners were getting mugged, even killed, during such dealings. To save their miners and reduce crime, the mining company now allows buyers to enter mine property one day a month, under the watchful eye of a horde of armed guards, to buy from the miners. We happened to be there for one of those days.

As many as 100 miners and twice that many buyers milled about on the company soccer field, really a big dirt patch, wheeling and dealing in emeralds. I was running all over the place getting pictures and looking at emeralds. All this was possible because I had two escorts, our hotel owner/driver, who, unbeknownst to me, was armed, and his brother, who had been with us since our arrival but never said anything. I found out later he was retired from the local mafia and was highly respected. He died some months after we were there.



The black, shaley rock is easily broken in search of the emerald-bearing calcite veins.

There are two ways you can spot the local emerald area mafioso. The hired killers wear black cowboy hats; there's nothing secretive about them! The mafia members all have pigtails, which they hang over their left shoulder. This signals everyone that you do not mess with that person.

I was rushing about taking pictures when José came up to me and said in a very stern voice, "Get in the truck, *now!*" I didn't argue, not with all those guns hanging about.

As we drove out the gate, someone sitting there yelled something in Spanish. I asked José what the guy said. The answer was, "Take care of your rich gringo!" Seems the rumor had started that the camera bag on my shoulder was full of cash and I was looking for a big crystal. We drove for about three hours before we were sure we had not been followed.

Another day, we went to Cosquez, site of one of the really big open-cast and underground mines. Again, we were able to go underground and see the mining of emeralds.

After we left that mine, we were dropped into the local town square because José wanted me to see a statue of the local priest who had negotiated a peaceful end to the miner/drug dealer war that had plagued the place. It seems the drug dealers were buying emeralds with dope, which was a lot easier to sell legitimately.

I was in the town square taking a picture of the priest's statue when a local law officer came out of his office and yelled in Spanish, "The guy with the camera is a drug agent!" Now to be called a drug agent is to have a target painted on your back! Again, José yelled, "Get in the truck, *now!*" I did!

After an adventurous 10 days in emerald country, it was time to head for Bogotá. The flight back to Bogotá was really uneventful, thank goodness!

finally coming to rest in this gravel embankment. Of course, the puzzling thing about this is the very fact that some crystals are heavily water worn, while others in the same deposit are pristine. The Ekstrom sapphires are found in a gravel embankment intermixed with eroded boulders, clay, and smaller rocks of various sizes that came to rest there sometime in the distant past.

It would take much more space than is allowed here to give you a more detailed picture of our fantastic four days at the sapphire diggings. We worked each day during the morning hours and then spent more time after lunch digging, screening the gravel in the creek, and searching the screens for those precious gemstones. That first full day was very successful for me. I found a rare sapphire, a beautiful purple one just under 3 carats!

Dean and Renee were using a screen positioned on a stand, while Gary and I screened by hand in the creek. The screens I used are about 14 inches square. The top one is ½-inch mesh and the bottom one about ⅛-inch mesh. After dipping and shaking the loaded screens in the creek, the ½-inch material is discarded, and the screen is set aside after being carefully checked for the possible rare, larger crystal on top. The bottom screen is washed a bit more, then a foam backing is placed inside and covered with a piece of plywood the size of the screen. The unit is then flipped over onto a flat surface. The screen is carefully removed and the search begins. If done correctly, the sapphire crystals should rest right on top.

That first morning, when I turned the screen over on the flat knee-high boulder I was working on, you can imagine my surprise to see that beautiful purple sapphire glistening in the sun near the center of the screen.

Digging, screening and washing sapphire-bearing gravel takes physical work, and it works up an enormous appetite for that great home cooking in camp. Of course, Dan can't take all the credit. His mother made apple and peach pies for our trip that only an expert can prepare, and Retta prepared a delicious chicken dinner, along with other goodies.

During our stay in camp, we all found sapphires. Renee recovered some magnificent crystals, including the largest gem-grade find of the trip, a beautiful light blue stone weighing an astounding 6.5 carats. It doesn't show any crystal faces, having been subject to the forces of nature for a long time.

Renee and Dean Dutton screen and wash sapphire-bearing gravel in the shallow creek near camp.

She and Dean also recovered, in the very next screen, another beautiful, flawless blue stone almost as large as the first one.

As we toughened up to the task of digging and screening gravel, we found more crystals. Renee found three in one screen. I found two in my screen one day. Gary found a very nice stone, but it somehow got away from him and was lost in the creek. He did, however, find others during our stay. Tom took time out from his many duties to recover a very nice crystal.

Each day after working at the diggings, we had a buffet-style lunch where we made our own sandwiches and salads from a great variety of luncheon meats, greens, and vegetables. The evening meals were fabulous and always served hot. After supper, we relaxed around the campfire in comfortable folding chairs and talked about some of our experiences, the day's events, and what our plans for the future were. It was often quite dark when we reluctantly went to our tents. The stars are so much brighter than those we see at home. The Big Dipper and many other constellations that I recognized stood out brilliantly in the night sky.

On our last day in camp, I had the good fortune to find more sapphires. On the very last screening that afternoon, I was surprised to see a beautiful, pink, hexagonal crystal resting on top of the gravel. It shows no sign of any wear and is blunted off, with perfectly flat ends. All in all, Renee and Dean went home with 10 beautiful sapphires. I found 21 crystals, all gem grade and flawless. Some are under a carat in weight, with the largest near 3 carats. They vary in color from light green to pink to light blue and purple.

Our evening meal on that last day consisted of charcoal-grilled porterhouse steaks so tender we could cut them with a fork, baked potatoes, salad, and all the trimmings, plus Dan's mom's delicious homemade peach pie.

The return trip was a repeat of the first and we arrived without incident at the ranch that evening in time for a feast, which was placed before us on a long banquet table in the main room of the lodge. Gem-grade sapphires and meals fit for a king: what more could one ask for?

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